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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · JULY 24, 1961

hot engine stresses brought to light... SEE

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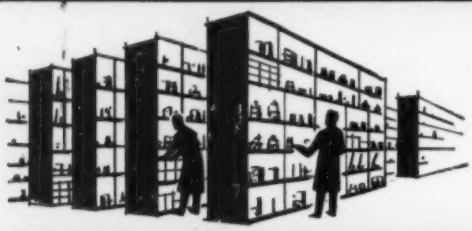
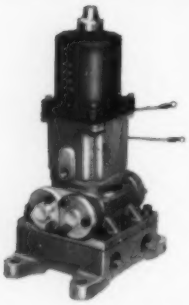


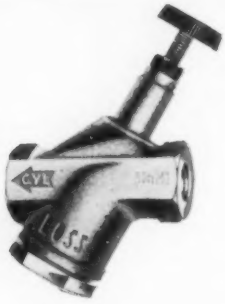
The stock shelves at **Ross** include more different air valves than any other stock shelves in the valve world

Do you know these air controls by **Ross**?



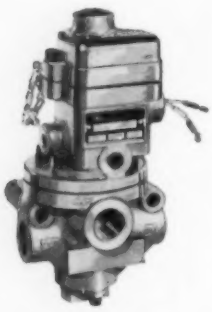
50 Million Cycles in Tests

Ross Goldmodel. A lightning fast, base mounted valve with its solenoid immersed in oil to run cool for long, long life. Full JIC. 3-way, 4-way and 4-way 5 port models. ¼" through 1¼".



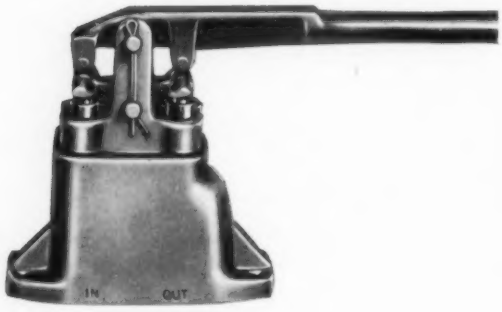
Control Cylinder Speed

Speed Control Valve. The adjustment screw directs air through an orifice that's engineered to give fine shadings of control at either high or low flow rates. ¼" through 1¼".



Does a Big Valve's Work

"Headline Series". Highest capacity valve-size for valve-size of any valve we've seen. Use a smaller, economical inline valve to do a bigger, more expensive valve's work. Fast. S-way, 3-way, 4-way. ¼" through 1½".



Especially for Tough Duty

Ross #100 series. Rough, tough jobs call for this valve which can pass most dirt and foreign matter with no trouble. Few moving parts and short poppet travel makes it especially wear resistant.

FOR OTHER ROSS VALVES SEE SWEET'S PRODUCT DESIGN FILE

The most complete line of air controls in the world

ROSS OPERATING VALVE COMPANY

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CIRCLE 173 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

July 24, 1961 Vol. 32, No. 30

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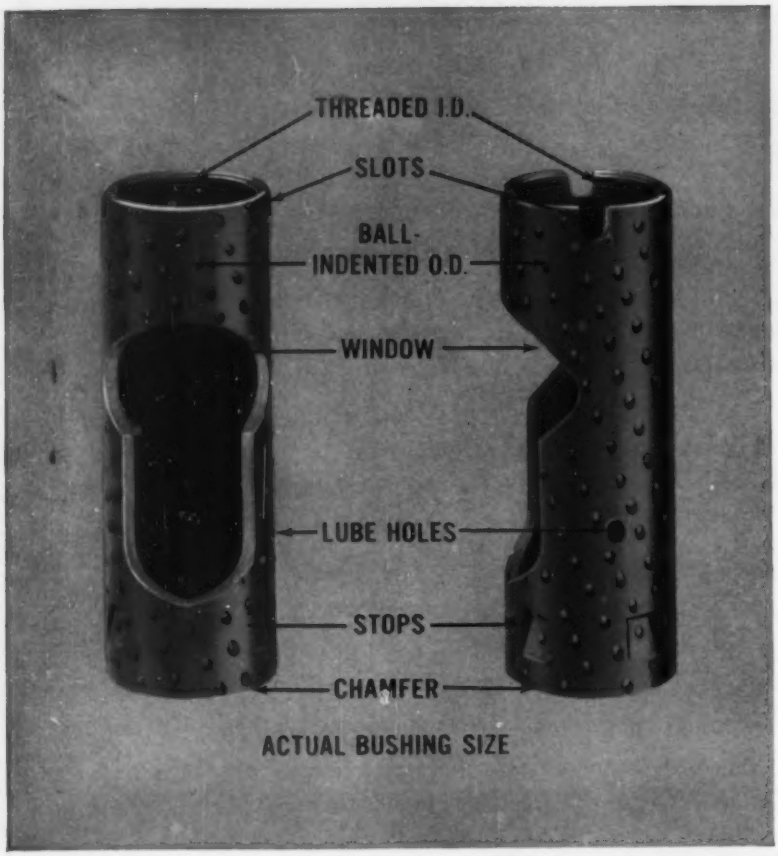
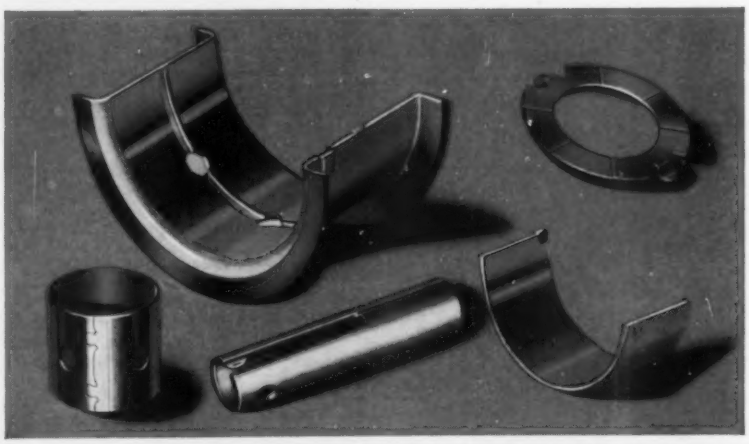
"EXOTIC" BUSHING MAKES NEW STEERING DESIGN COME TRUE



INSIDE-OUT BUSHING HELPS PUT NEW STEERING MECHANISM INTO PRODUCTION! To perfect a new steering mechanism, an automotive manufacturer required a linkage component. Designers tried making it of machined steel, then plastic . . . both materials failed. But the unusual bushing shown at left, with a number of features F-M engineers helped designers incorporate, solved the problem. It is bronze-on-steel, formed with the ball-indented bronze on the O.D. so the bushing can accommodate sliding motion within the mechanism. A large window makes insertion of a ball socket easy during assembly. Design of the bushing also includes: stops near one end to hold a disc . . . a threaded I.D. on the other with slots for a locking pin . . . holes that supply lubricant to the outer surface. For the F-M customer, all these built-in features helped accomplish this result—easy, efficient assembly and success with a new design.

CAN F-M BUSHINGS SOLVE problems on your board or on your assembly line? Or perhaps a sleeve bearing, thrust washer or spacer? F-M, who makes them all, can provide the answer. F-M engineers, with a wealth of knowledge from years of experience, are available to help design the needed component. This complete technical assistance is one reason why these F-M products are widely specified for use in automobiles, farm equipment, construction machinery and many other products.



Additional information about bushings is provided in a Design Guide, published by F-M. Helpful literature is also available on sleeve bearings, thrust washers and spacer tubes. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan.

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bushings-spacers
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DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

INTERESTING TO NOTE

On our cover—Herb N Maier, (left), chief physicist, Doehler-Jarvis Div, National Lead Co, and Dr Felix Zandman, director, research and development, Instrument Div, The Budd Co, analyze stress conditions in the '61 Rambler cast-aluminum engine as shown by the PhotoStress technique. The engine is coated with a double refracting plastic, and color patterns caused by strains are observed and measured through a polarizing instrument. This method enabled Doehler-Jarvis and American Motors to redesign the engine in just over three months (see page 42).

Although colors have played a large part in design, this test is one of the few examples where colors are used as a quantitative measure rather than an aid to product appearance.

There was a time when Henry Ford sold Model T's in any color "just as long as it was black." He felt that colors meant so little to the consumer, they might as well be standardized. Automakers have since proved that the demand for color can be cultivated in the consumer to such an extent that a black car has become a rarity in this country. The telephone companies have also shown how color can mean added profits. Since the introduction of color phones more than ten million have been installed in American homes and offices. About 40% of all phones are in color. It's quite a sales gimmick since the color telephone, costing about $10 extra, is mechanically identical to the plain black phone. Curiously, the most popular "color" phone is white.

Color researchers have come up with some interesting findings to explain how color effects our buying patterns. Brown will sell coffee, baked beans or tobacco, but it won't do a thing for hardware which moves fastest against a blue backdrop. Blue won't sell food. On a margarine package, a cake of blue ice meant mood indigo for the manufacturer, but the housewife associated blue ice with something cold, lifeless, unnatural. A new package showing the bar of margarine against a background of colorful flowers evoked the more positive associations of life, health and nature—sales went up.

One of the oddest aspects of color psychology is the way different nations look at color. White, not black, was the color of mourning in ancient Rome as it is in modern China. Red meant heaven to the ancient Chinese; it meant goblins to the neighboring Tibetans. Blue is hated by an Armenian tribe of nomads—their worst curse is "May you die in blue garments."

continued, next page

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The mystery in Rutherford's lab

Of all counters, (see p 29, for an article on mechanical counters) the most famous is the one developed by German scientist Hans Geiger. Its familiar click—now synonymous with the age of space and atoms—recently uncovered a mystery at Canada's McGill University. A graduate research student happened to be carrying a Geiger counter from one room to another. He had unwittingly left the instrument on and was surprised when it suddenly began to click. The readings indicated that he was in a "hot" area. He immediately notified Dr Fernand Terroux, associate professor of physics, and former student of Lord Ernest Rutherford.

In the early 1900s Rutherford had used a laboratory at McGill for some of his experiments, and it was first thought that the "hot" area was a cupboard used some 50 or 60 years ago to house Rutherford's liquid radium compound. The woodwork was ripped out and analyzed —to no avail, the trouble lay elsewhere. Although no dangerous levels of radiation were discovered, it was decided to call in the Army. A survey of the building disclosed the fact that the source of radiation had nothing to do with Lord Rutherford or his students. It turned out to be an assortment of luminous instrument dials used during the war for research in night blindness. The dials were promptly sent to Atomic Energy of Canada Ltd, at Chalk River for safe disposal.

In some cases counters are only as good as those who calibrate them. The curiosity of a messenger boy recently provided the point. For months Daniel Cifor made in-plant deliveries at Lockheed Aircraft Corp's Calif plant. Among his deliveries were boxes of staples marked "5000 per box." for months, each time he made deliveries, his curiosity increased: Were there really 5000 staples in each box? There was one way to find out—count. This he did, using his desk for a full week as a lunch-period research center. Cifor ciphered away and found 104 fewer staples per box than marked. His finding, confirmed and commended by Lockheed's material organization, was further substantiated by the staple manufacturer.

Automatic counting devices, it seems were erroneously recalibrated when the firm changed to a heavier wire. Since the division buys 10,000 boxes, or approximately

50,000,000 staples, a year from the company, the 2% shortage Cifor discovered would amount to 1,000,000 staples.

The manufacturer re-recalibrated its counting machines, and sent a letter of appreciation for discovery of the error, plus 140 boxes of no-charge staples to make up the deficit caused by the wire change. The staples are worth 38¢ per box—a total of $53.20. —Benedict A Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . How to heat air for testing

Heat-test your product at any temperature from ambient to 500,000 F using air as the medium with the right heating method.

. . . Can you ignore numerical control?

Simpler control systems and new production concepts—here is what has been happening in this fast-moving field.

. . . Strength of metal-powder parts

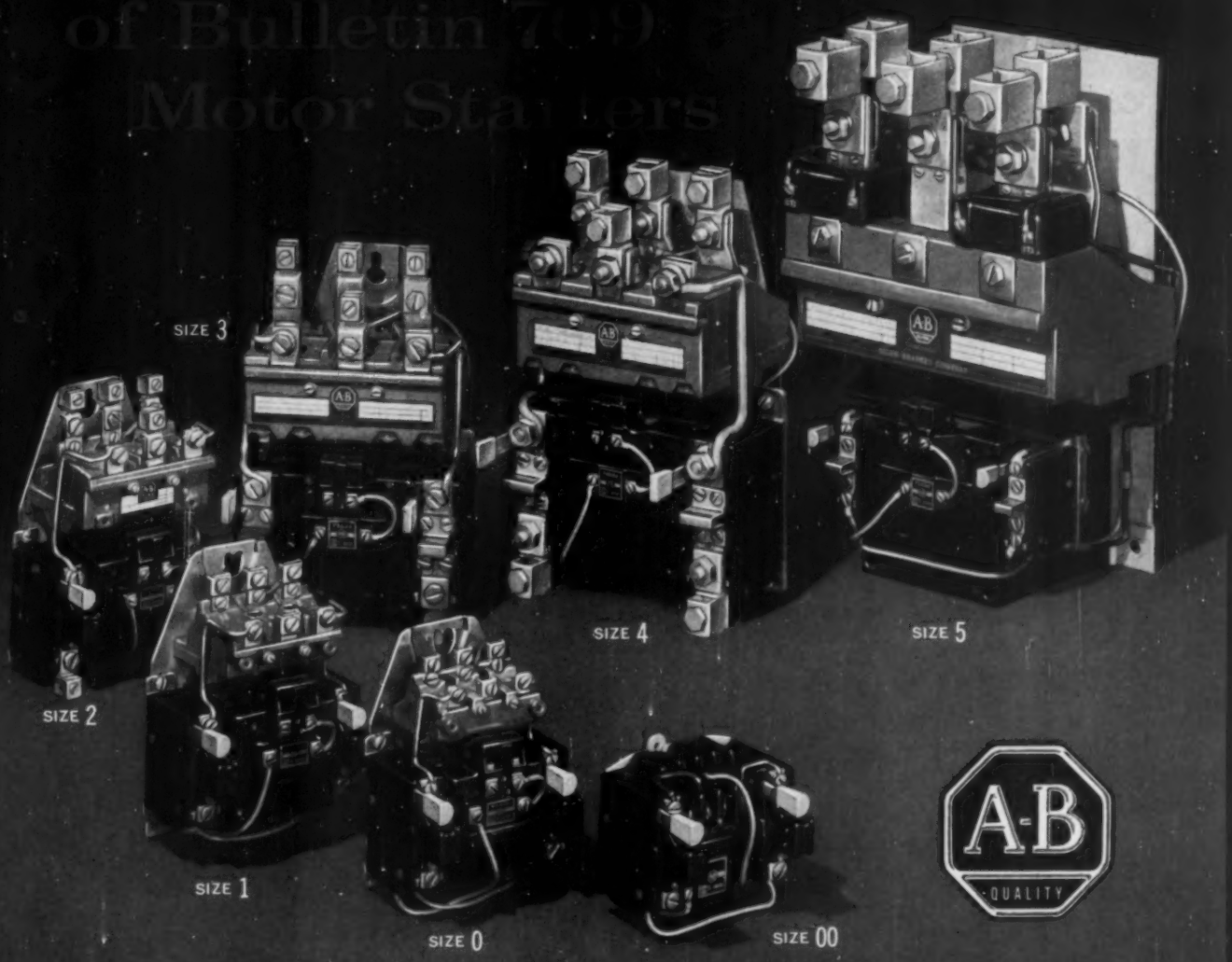
Straight-line relationship between strength and hardness is characteristic of sintered metal powders.

. . . What you can do with nonstandard spur gears

Altering pressure angles offers increased freedom in selecting center distances, gear ratios and speeds.

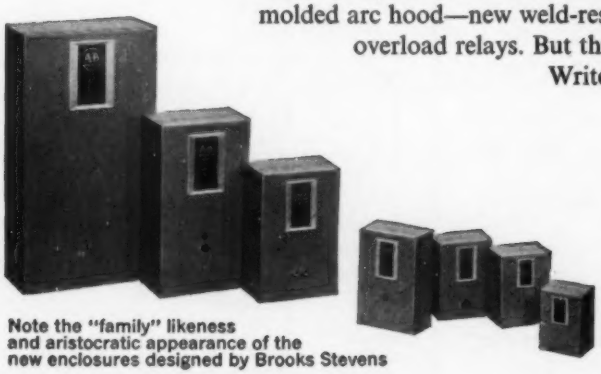
. . . Designing flat springs—unit resilience and spring-rate

The factors that fit these 8 single and leaf springs to the nomograph also furnish a ready means of comparison.



the greatest advance in motor control in 30 years

From their amazing compactness to their almost unbelievable operating life—measured in *millions* of operations—this entire family of Bulletin 709 solenoid starters is *new in every detail.* They feature a new, patented, high-efficiency magnet—new molded coil—new hot molded arc hood—new weld-resistant contacts—and new truly *trip-free* and *tamperproof* overload relays. But these new starters use the old Bulletin 709 heater elements. Write today for all the details on this really amazing new line of Allen-Bradley Bulletin 709 motor starters.



Note the "family" likeness and aristocratic appearance of the new enclosures designed by Brooks Stevens

ALLEN-BRADLEY

Member of NEMA

Quality Motor Control

Allen-Bradley Co., 1329 S. First St., Milwaukee 4, Wis.

CIRCLE 5 ON READER SERVICE CARD

DEVELOPMENTS TO WATCH...

Coatings stand 5500 F

Thermal ablative coatings that provide short-term protection against high-velocity heat blasts at temperatures of 5500 F; and new fire-retardant paints are among the new special-purpose finishes being developed by Empire Coatings and Chemicals of Denver.

The thermal coatings are two-component epoxy-polyamide systems, designed for direct application by brush or spray, without special primers. Empire says they show excellent adhesion to ferrous and nonferrous alloys as well as nonmetallic materials. A 60-mil coating will protect 0.050 aluminum from direct heat blasts (5500 F) at Mach 4 velocity, and hold back-side temperatures as low as 150 F.

The fire retardant paints, now being marketed commercially in both flat and enamel types in a wide range of colors, are intumescent materials that first bubble and then char. Empire says they'll protect wood—and even cardboard—from direct blowtorch heat for 5 min or more and will reduce burning in tunnel tests to a very small fraction of the standard rate.

New speaker to improve acoustic devices

Loudspeakers with a thickness of less than ¼ in. are proimsed by Emerson Radio as it tackles commercial development of a new transducer invented in Israel.

Emerson claims, that the principle on which the new design is based will permit significant improvements in microphones, hearing aids, and other acoustic devices. Heart of the new speaker is an "isophase transducer," which is said to have a large, flat diaphragm in place of the conventional cone, the diaphragm being so arranged that "it moves as one piece and transmits energy to the air."

Emerson says it is also developing a new woofer that is expected to permit design of speakers and enclosures about ½ the size of those on the market and yet "considerably superior" in performance.

Additional details are lacking because, Emerson says, design work is not yet complete and patents have not yet been obtained.

Better properties for nylon

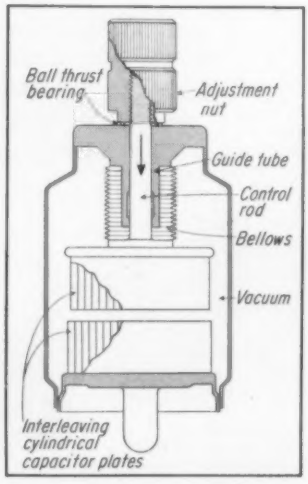
Oxidation resistance of nylon can be improved and elongation reduced, GE engineers find, by subjecting the plastic to relatively low-level radiation at moderate temperature (below 212 F). The radiation treatment alone changes the elongation; but, to develop the improved oxidation resistance, an annealing treatment (at 212 to 432 F) is needed. A British Patent has been filed; but the process, is not yet in commercial use.

Czech capacitor claimed more compact, easier to produce

A variable, vacuum capacitor designed in Czechoslovakia is claimed to be less bulky than conventional units and easier to produce because evacuation is simpler.

Key to the design is location of the control rod-and-tube assembly inside a bellows driven forward by a lead screw and nut working against a ball thrust bearing (see diagram).

The capacitor electrodes are made up of a number of concentric cylinders which interleave when the upper electrode has been driven down to the end of its travel. B. Klen of Prague is named as the inventor. The Czech patent: 95,419.

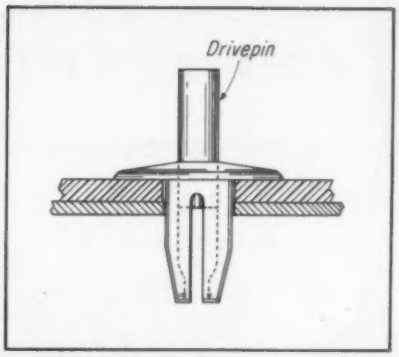


VARIABLE CAPACITOR plates work in vacuum. Ambient air pressures inside bellows holds upper electrode down with a constant pressure, keeping adjustment nut tight against can.

More fasteners in plastics

The growing use of plastics in structural applications, and the demand for corrosion-resistant assembly systems for metals, is sparking a host of new fastening ideas in plastics.

Examples: cold-headed acetal rods to replace rivets in impeller assemblies (*PE*—June 12, p 23), self-locking and self-sealing rubber and nylon grommets (*PE*—Dec 26 '60, p 8 and Apr 10 '61, p 9) and such assemblies as the one diagramed here. It's a blind rivet made of nylon for such applications as fastening refrigerator panels to frames. United-Carr Fastener has filed a patent application on the system, says it is superior to snap-in rivets, particularly when the pressure required to seat the snap-type rivet might move the supports or buckle the panel itself.



BLIND RIVET ASSEMBLY consists of hollow-bored, slotted shank and pin. Unit is assembled by passing shank through prepared holes, then pushing drive pin through until it is flush with the flange. As it is pressed home, it expands the lower, tapered portion of the bore, locking the rivet in place.

Stronger copper parts from powder

Powder metallurgy techniques may prove as valuable in improving the performance of copper as they are in aluminum. That's the key point in a Soviet report just released in full English translation by NASA.

Like sintered aluminum, the sintered copper product is considerably stronger and harder than cast metal at both room and elevated temperatures. Addition of alumina powder to the copper can bring even further improvement.

The strength of sintered copper parts containing 1 to 3% aluminum oxide is said considerably to exceed that of copper alone at temperatures all the way to 1470 F—in many cases by as much as 50%. (Average tensile strength of sintered copper powder parts containing 3% alumina was about 40,000 psi at room temperature. At 1470 F, it was still above 7000 psi. Furthermore, hardness increased 2 to 3 times; and there is surprisingly little reduction in electrical conductivity—only about 7 to 13%.)

Copies of the report (TT-F-64) may be obtained from NASA without charge by government contractors. Sale copies will be available to others from OTS, Dept of Commerce, Washington 25, D. C. (Price—50¢).

More high-strength steels on the way

An ultrahigh-strength low-alloy steel that "ranks foremost in its category", shows a uniaxial yield strength (0.2% offset) "in excess of 300,000 psi," an ultimate tensile strength above 350,000 psi, and "adequate ductility" is reported by Mellon Institute. It's an improved version of Rocoloy 270, a 320,000-psi uts alloy also developed at Mellon. Both alloys are said to show fabrication characteristics (deep-drawing, spinning, forging, rolling) similar to AISI 4140 and AISI 4340; and the newcomer "surpasses the uniaxial tensile properties developed by AISI H-11 steels at both room and elevated temperatures."

Mellon estimates that, with the new steels, it should be possible to reduce deadweight in structural components of space vehicles by as much as 40%, and increase payload proportionately.

Work is continuing, under Navy sponsorship.

New machines to improve molded plastics

Better thermoplastic parts are promised as molders adopt new machines that combine some of the features of extruders with the standard molding unit. Instead of a plunger to move the material along, they have a rotating screw (*PE*—June 26, p 25). Advantage: materials can be moved at lower temperature; don't hang up in the cylinder and overheat. PVC and other relatively heat-sensitive plastics are expected to benefit most. HPM, Lombard, Standard Tool, Stokes, Reed-Prentice and Watson-Stillman are all working on machine designs. —ARG

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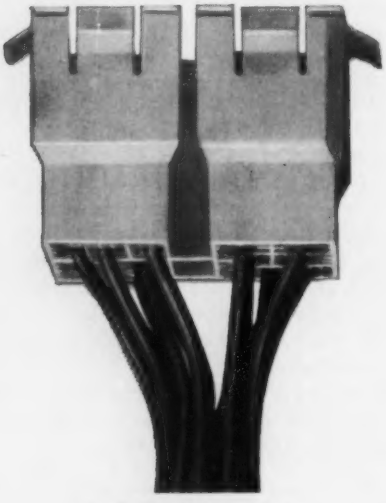

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AMPEEZ*

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- "Tab-Gap Lok" prevents contact spread
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- amperage rating 20-25
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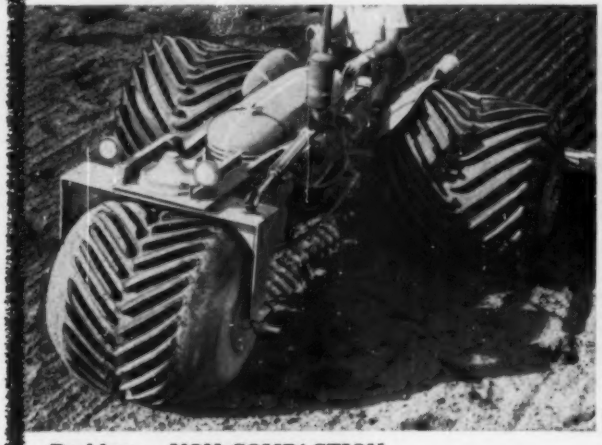
Terra-Tires solved problems on this equipment— How can they help you in your design?

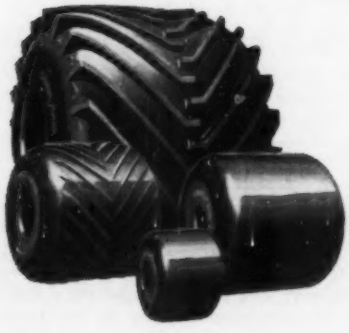
Problem: MOBILITY
Solution: Terra-Tires by Goodyear. Their wide tread, low inflation pressures and high flotation let this truck, owned by Shell Oil Company, easily pull free of a deep bog during an oil exploration.

Problem: FLOTATION
Solution: Terra-Tires by Goodyear. An Indiana company put Terra-Tires on this scraper to prevent delays caused by equipment miring down. Result: Faster peat harvesting at lower cost.



Problem: NON-COMPACTION
Solution: Terra-Tires by Goodyear. A racetrack that's uneven can damage thoroughbreds' legs, so Santa Anita uses tractors with Terra-Tires to condition track after a rain without compacting ground.

Problem: CARGO PROTECTION
Solution: Terra-Tires by Goodyear. Bananas bruise easily, so United Fruit "floats" its fruit from farm to railhead on equipment fitted with Terra-Tires, which also permit all-season hauling.



If you're designing a "go-anywhere" vehicle – or one that must baby its cargo or the ground it goes on—Terra-Tires by Goodyear should be a part of your design. They're available in a wide range of sizes and treads. Let us know what you're driving at—or on—or over, we'll be glad to suggest a design to solve your problem. Write Goodyear, Aviation Products Division, Dept. G-1720, Akron 16, Ohio, or Los Angeles 54, California.

Lots of good things come from

GOODYEAR

Terra-Tire—T.M. The Goodyear Tire & Rubber Company, Akron, Ohio

WHAT'S HAPPENING IN RESEARCH . . .

Rate-of-cure changes bring new properties

The rate at which adhesives are cured, and the rate at which carbon is heat treated can have marked effects on performance of these materials.

Two reports, from widely different sources, tell almost the same story.

From a Naval Research Lab study of the effects of irradiation on organic adhesives comes a strong indication that the rate of cure—the actual processing method applied before irradiation—substantially affects radiation resistance after the adhesive is in use. Electrical properties are more seriously affected than mechanical performance.

Preliminary tests—on epoxy adhesives exposed to high-energy radiocobalt sources—indicate that the reduction in resistivity after 24 hr exposure at a dose rate of 1.5×10^8 roentgens/hr will be close to 40% for resins cured by standard methods. But samples cured slowly at low temperature (5 hr at 200 F) show much less reduction than do those cured at the higher rate.

Studies of carbon at Tokai Electrode Mfg Co in Nagoya, Japan, tell of another interesting rate-change effect. When carbon is heated very rapidly to 5000 F electrical conductivity, thermal expansion, real and apparent density are all below the values for carbon heat treated by normal methods. And, the Tokai researchers say, the "normal" properties can not be restored by re-heat treatment under normal procedures.

New shape for single crystals

Single crystals are being grown in spherical rather than whisker form at Oak Ridge National Laboratory. The aim: to obtain more perfect specimens for radiation tests.

When the crystals are free to grow without the external constraints of a crucible containment shell, except for point contact on a nearly planar surface, the spherical shape is created by surface tension.

In a report prepared for the American Physical Society, M. C. Wittels and F. A. Sherrill of Oak Ridge say the technique has already been applied to copper, silver, and gold and some of their alloys, and transmutation (gold into mercury, for instance) as well as radiation damage studies are under way.

briefs . . .

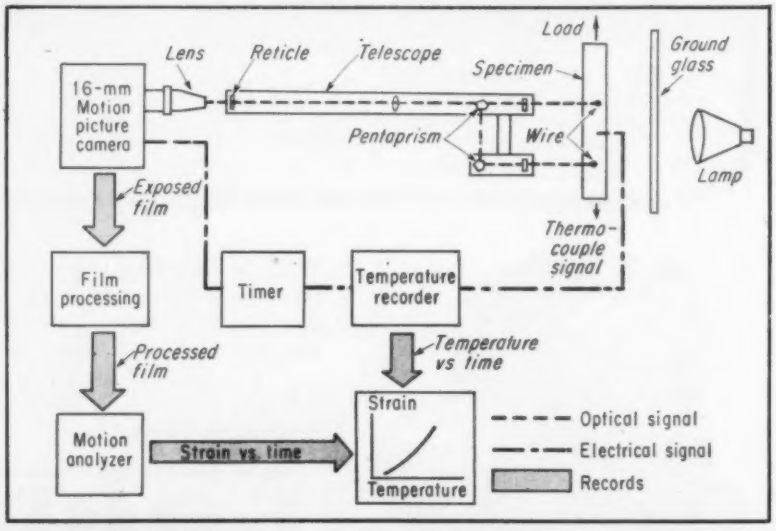
Corrosion of magnesium in superheated water can be reduced, AEC researchers say, by adding about 0.7 ppm of sodium fluoride to the water. Thus a fluoride coating is formed in the system. Addition of hydrofluoric acid to maintain the pH at between 6 and 7 increases effectiveness. AEC has patented the system (2,970,885) and is making information on it available—nonexclusive and royalty-free.

A pneumatic "skin effect," analogous to the electrical skin effect encountered in hf transmission lines, is postulated by N. B. Nichols of Taylor Instrument. He told the Joint Automatic Control Conference that he believes this effect rates consideration in design of pneumatic process-control instruments and other pneumatic equipment, and he has worked out equations for velocity distribution and other factors. **—ARG**

Optical system measures stress

For tensile and yield measurement at elevated temperatures, NASA's Langley Research Center has devised an optical system that actually increases in accuracy as the strain increases. Furthermore, it seems particularly adaptable to tests under rapid heating conditions. It shows good correlation with extensometer measurements; and, C. R. Manning, Jr. and H. L. Price report, it avoids the inertia effects of mechanical systems.

For the test, samples are prepared by spotwelding 0.008-in. wires (1 in. long) to the center line of the specimen at 2-in. intervals on one side. As the specimen is stressed, the position of the wires changes and is observed through the optical system shown in the diagram. The image on the reticle is photographed life-size on 16 mm motion-picture film, and the exposed film is read on a motion analyzer which measures the distance between silhouette images. A strain-time plot is thus obtained. Thermocouple signals, fed into a strip recorder, provide a temperature-time plot. From the two plots, the strain-temperature curve is constructed.

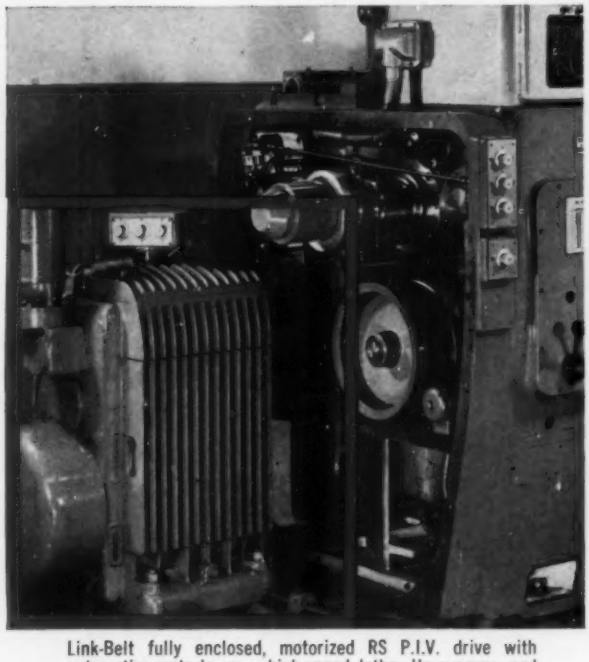


OPTICAL SYSTEM for strain measurement has ground glass that serves to silhouette wires, and prism system to superimpose images in the telescope. Timer (one pulse per sec) correlates photographic film and temperature record.

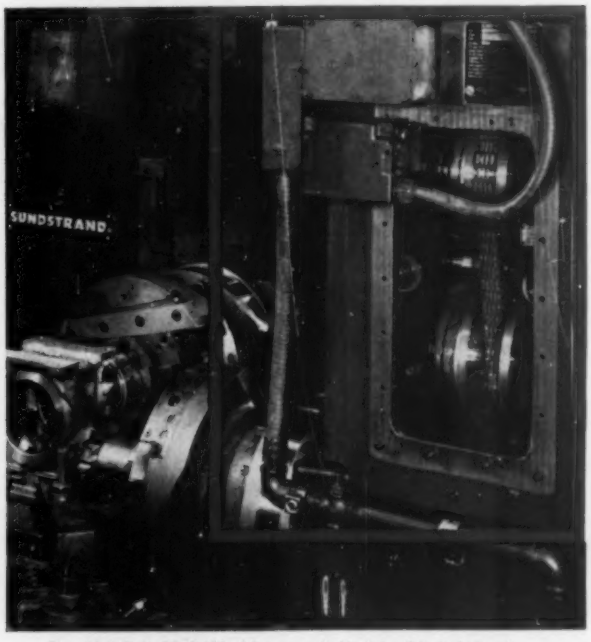
Only Link-Belt RS P.I.V. variable speed drives give you all three:

compact design
constant horsepower
capacities to 50 hp

Separately mounted . . . . . or built-in types



Link-Belt fully enclosed, motorized RS P.I.V. drive with automatic controls on a high-speed lathe. Horsepower and surface cutting speed are constant to suit turning and facing operations.



Two Link-Belt RS P.I.V. drives are built into this twin-head, right-angle automatic boring machine. The spindle in each head is individually controlled to meet the requirements of each operation.

Higher hp capacities in an extremely compact unit—that's what you get with Link-Belt RS P.I.V. variable speed drives. For direct-drive variable speed transmission, these units provide smooth, stepless speed control—precisely and infinitely variable over the entire range from maximum to minimum settings.

With capacities up to 50 hp, Link-Belt RS P.I.V. drives offer speed variation ratios as high as 7 to 1. During many years of service they have proved their dependability in heavy-duty industrial installations . . . and in systems involving automatic control or programming. Construction is all-metal, with dependable oil lubrication.

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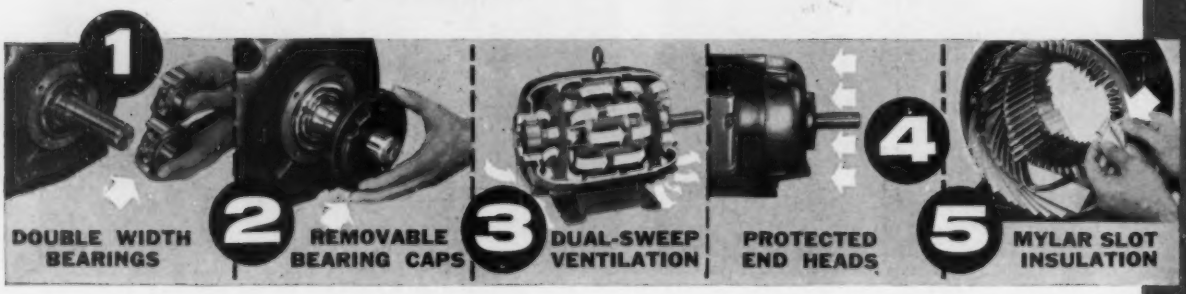
WHICH R&M MOTOR FEATURE WILL ADD MORE TO YOUR PRODUCT'S *COMPETITIVE ADVANTAGE?*



All these outstanding features—*yours at no extra cost*—contribute to R&M's dependable performance, easy maintenance and long life. Fully sealed double-width bearings have extra-large reservoirs containing grease selected to resist dust, temperature, humidity and high speeds. Bearing inspection and relubrication are easy. Bearing cap on each end head comes off quickly when four bolts are removed. Bearing seal, held by removable snap rings, is also easily removed. "Dual-Sweep" ventilation greatly prolongs motor life with high-velocity cooling and cleaning. Tandem fans—one pushing, one pulling—create end-to-end ventilation that eliminates "dead" areas. Venturi baffles direct air over and around end coils. One-piece shrouded end heads give full-height protection against moisture and falling objects. Mylar* laminated to rag paper insures positive slot cell insulation because of its excellent dielectric qualities (8 times that of conventional insulation). Rag paper backing provides cushion against abrasion and puncture. Get complete information . . . write today for Bulletin 520-PRE

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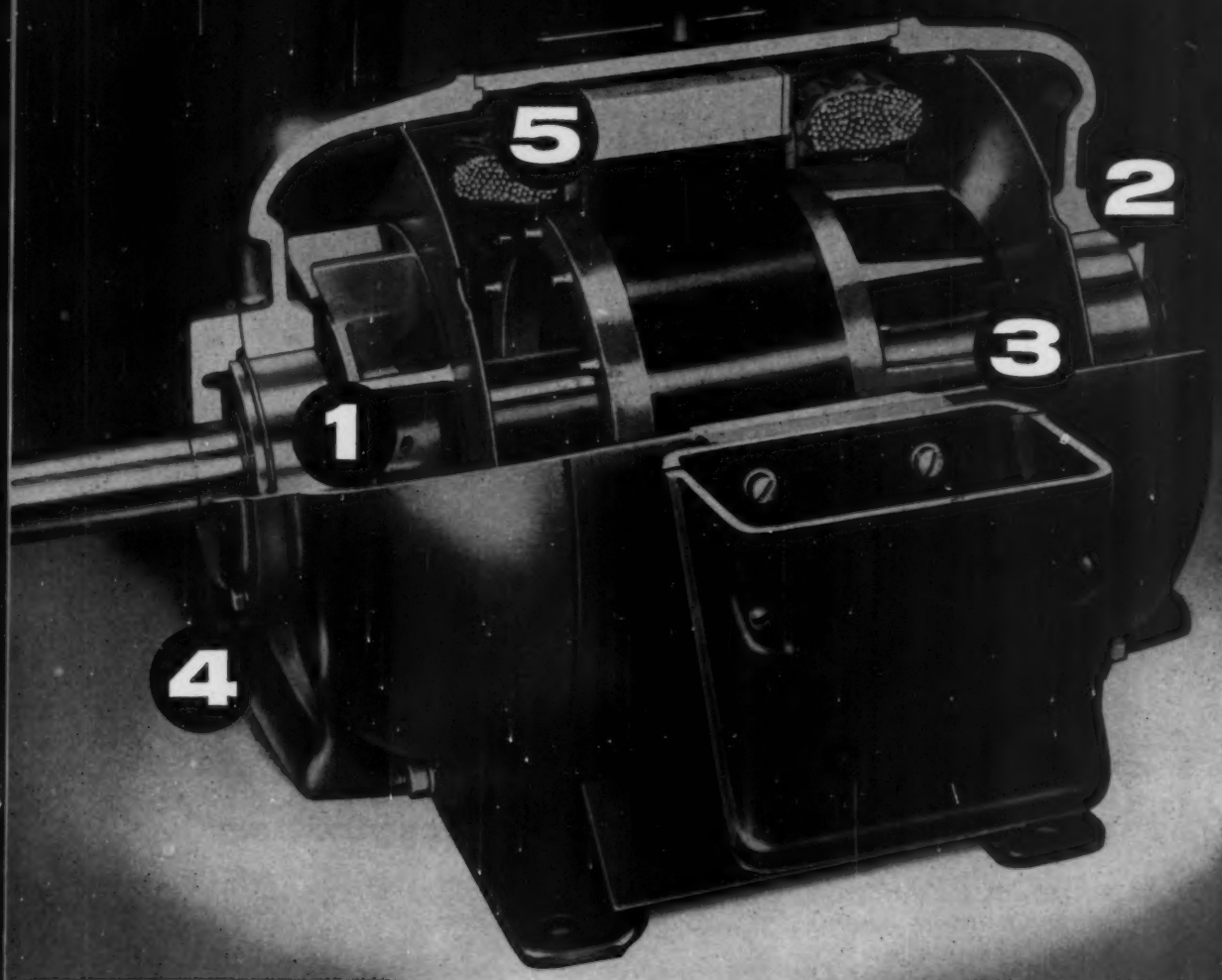
MOTORS 1 thru 200 HP

(other ratings 1/200 to 1 horsepower)

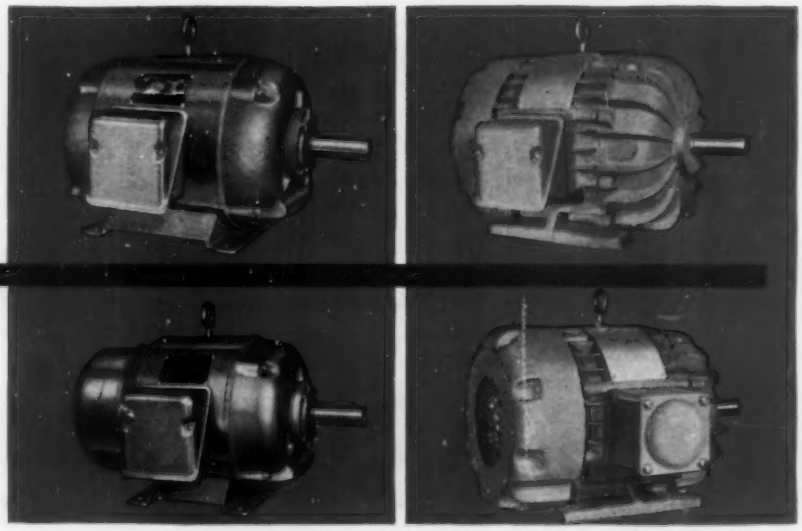


Open Protected Polyphase Motors (left), up to 200 HP, are suitable for many applications formerly requiring totally enclosed construction.

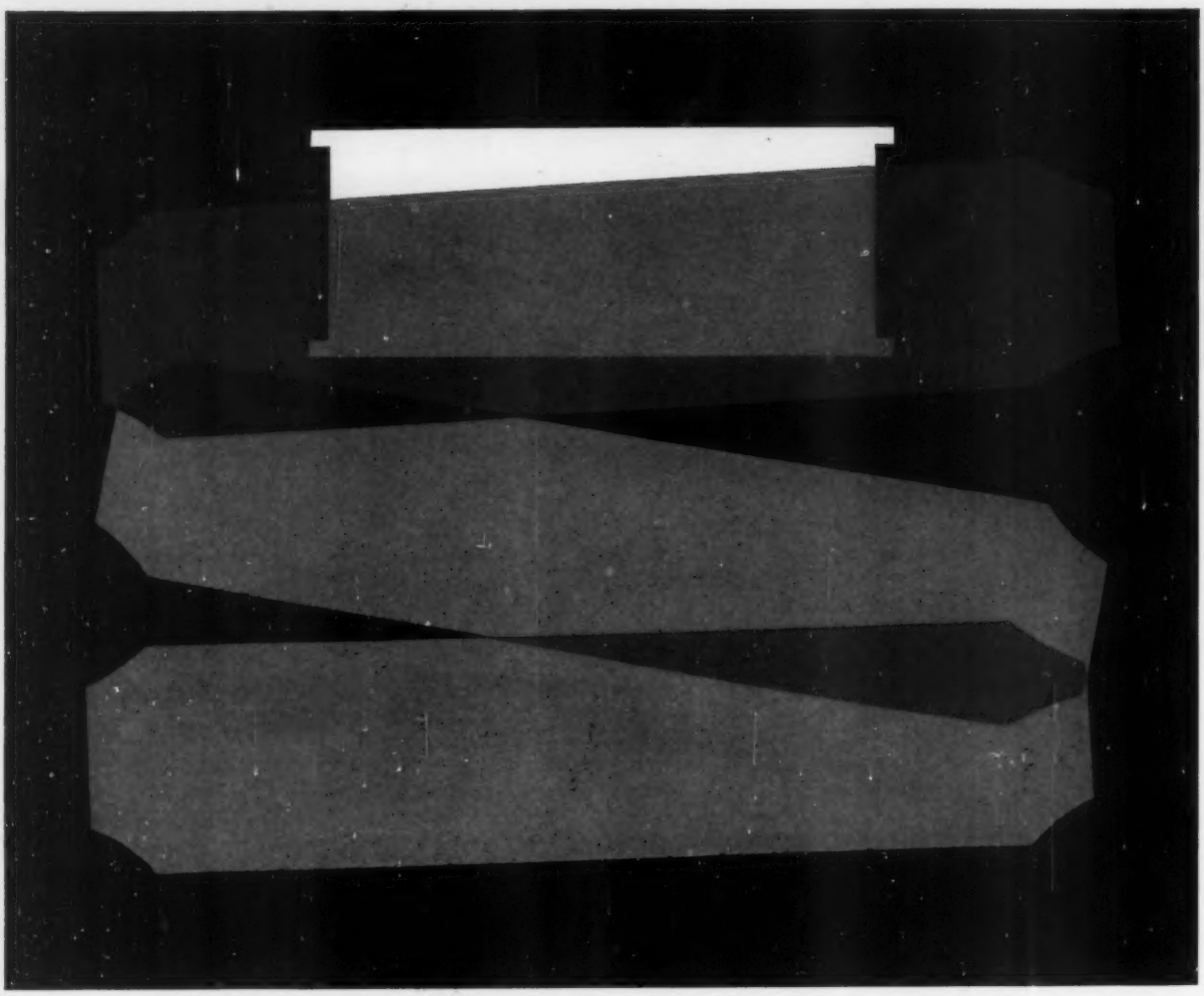
Totally Enclosed Motors (right), ½ to 200 HP, are fan-cooled . . . offer complete protection against all harmful atmospheres.

"PM" Single Phase Motors (left), ratings through 20 HP, eliminate maintenance because they are fully weatherized for severe duty.

Explosion-Proof Motors (right), ratings through 200 HP, are Underwriters' Approved for Class I, Group D, and Class II, Groups F & G.



CIRCLE 13 ON READER SERVICE CARD



How to loosen tire beads without perspiration

Firestone Airmount Actuators produce controlled force at a fraction of the cost of less efficient pneumatic devices.

Equipment actuated by Firestone Airmount now speeds and simplifies tire changing in service stations. Airmount's simple design eliminates short-lived mechanical parts in less efficient and more expensive bead-loosening machines, and actually helps cut their cost below that of *manual* units! Precision Airmount actuation has been proved in machines of many types, in many industries. Whatever your actuation, suspension, shock, or vibration problem, why not write us, Dept. 41-5 for a low-cost, long-term solution with Firestone Airmounts.

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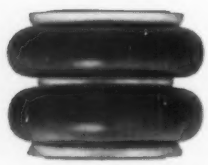

The Airmount in this Coats Company, Inc., unit inflates and generates actuating power to loosen tire beads in seconds. The operator has only to apply compressed-air pressure.

Firestone

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THE ENGINEERING WEEK

Servo system amplifies muscle power; promises many beneficial applications

NEW YORK—Human muscles are not obsolete. In fact they are now the focus of considerable research activity aiming to sense their electrical potentials to control motors that in turn drive mechanical systems.

When a muscle tenses, it generates electrical pulses or spikes known to bionics engineers as electromyographic (EMG) potentials. The integral of these signals, it has been found, is proportional to the tension developed by the muscle. On the other hand, when a muscle stretches or is at rest, no electrical activity can be detected.

Given this electrical behavior of muscles, researchers have demonstrated that muscle tension can serve as input for an open-loop positive control system. The electrical signal is shaped, amplified and used to drive a step motor. Such systems are progenitors of a truly integrated man-machine system.

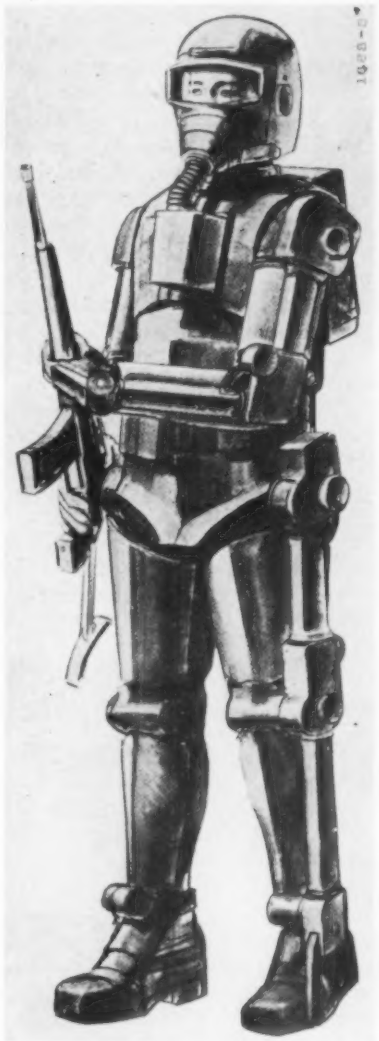
An intensive research program leading to practical application of the muscle's electrical activity was described here by Dr David O. Ellis and Frank Schneidermeyer of Litton Systems, Inc, Woodland Hills, Calif, at the International Conference on Medical Electronics. The two engineers found that EMG pulses have narrow spike-like amplitudes ranging from 0.1 to 2 mv. The normal frequency is about 50 pulses per sec, though they sometimes occur in bursts of 300 per sec or more. These pulses, Ellis says, actually represent the combined potential of many individual muscle fibers that have been stimulated by nerves near the skin.

At first, Ellis and his group amplified the pulses, then rectified and integrated them to drive a dc motor. This approach was unsatisfactory because the motor shaft rotated in proportion to gross muscular activity, and did not respond to low frequency inputs.

A solution was found by modifying the signals and using them to drive a stepping motor. In the system described at the conference, output from tiny metal disks on the skin (they must be tiny or signals from adjacent muscles will be picked up) are transmitted to a differential preamplifier. These pulses are converted to uniform width and amplitude and then used to activate computer-like logic circuitry which drives the stepping motor. Thus each spike calls for a predetermined shaft rotation.

The first breadboard model has a motor with 200 steps per revolution. Eventually, the Litton engineers hope to have smaller models of the stepping motor with 800 steps per revolution.

A number of improvements for this relatively crude system are under study. It must be made smaller and



A SERVO SOLDIER is one possible application for an EMG control system. Similar to his medieval counterpart, the soldier is protected by a mechanical suit, but unlike his predecessors, his natural body movements are powered by servo systems. This power amplification makes it possible for him to handle heavy airdropped cargo with ease and to run faster than usual in combat. The suit shown here has power-activated, splint-like attachments on arms, legs and torso. They are pivoted so the soldier can run, climb or crawl with ease.

Mohole project seeks industrial contractor

WASHINGTON—The National Science Foundation is looking for a prime contractor to take over Project Mohole. The project calls for drilling some 15,000 ft into the earth's crust at an ocean site where the water depth is around 18,000 ft. The purpose is to determine the inner composition of the earth.

Companies interested in acting as prime contractors for the program will meet in Washington on July 27 with the NSF for an industry briefing, then there will be a 30-day period for bid submission. Up to now, the project has been handled by the National Academy of Sciences—Research council. Now that feasibility of the program has been established, however, the National Academy wants to step out of the picture.

Work still to be done in the Mohole Project includes conducting deep ocean surveys, the design and construction of deep drilling equipment, and the drilling of a series of holes in the ocean floor, one of which will completely penetrate the earth's crust.

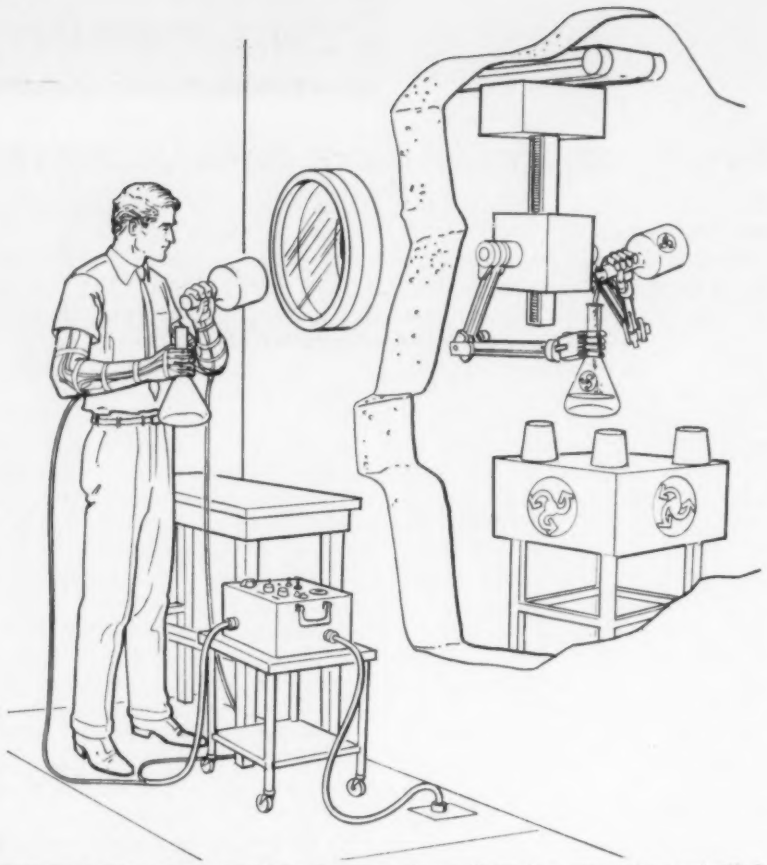
Cost of completing the Mohole Program is estimated at $5 to $10 million or more over the next two to three years. In fiscal 1962, $1 million has been budgeted for continuation of the program. ■

less complex to be practical, Dr. Ellis says. Several small aircraft stepping motors are under consideration. They sacrifice motor torque but have the advantage of fewer components.

Still further in the future, the present open-loop servo may be replaced by a feedback control system with the muscle as controller and controlled quantity. The muscle output voltage will be sensed, modified and then fed back directly—possibly by a myostimulator, a device that uses electrical energy to stimulate muscular movement.

Adaptations of today's breadboard open-loop model and tomorrow's closed-loop model have a variety of potential applications. They may be used to amplify the power of a person's natural movements. Or they may be used to control devices where natural movements are restrained as in an aerospace vehicle under high-g forces. In such cases, the pilot need not move his arms, but simply tense his muscles to adjust controls.

A very promising non-military application is in prosthetic devices. Suitably modified gross EMG may be used as a power source for driving low-power prosthetic devices. Or artificial limbs may be controlled by EMG signals obtained from muscles above the missing limb or from opposite sides of the body. ■



ROBOT ARMS HERE duplicate human actions through a remotely controlled servo system. Litton now has a local FM telemeter available, which the company says could be easily integrated into such a system.

Inexpensive gyro corrects missile flight paths

CHICAGO—Armour Research Foundation has developed a "poor man's guidance system" which corrects ballistic missile trajectories for wind or other external influences. It's said to give greater accuracy than the "free-rocket" method now common in short-range operational missiles. In such systems, the missile is given the thrust and trajectory to hit a target, but cannot compensate for outside forces.

The new guidance system consists of a 12,000-rpm flywheel in a single gimbal attached to the missile. The gimbal axis lines up along the flight path; the wheel axis at right angles to it. The gimbal turns on ball bearings and has a small weight on the top side that acts like an integrating accelerometer. The gyro weighs about 4 oz and is driven by a motor built into the wheel—actually a $6.50 war-surplus 400-cycle 28-v motor.

If wind or other force push the missile off course, the weight on the gimbal rotates the gimbal. The gyro then reacts, causing the missile to weathervane—turn its nose into the wind. Weathervaning allows aerodynamic forces to bring the missile back on course to the target.

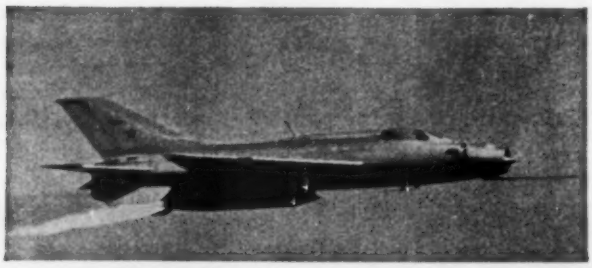
Armour has learned that aiming the missile only requires lining up the target within the plane of the wheel, then using one of several available means to adjust the range. High-speed movies taken of many flights show that weather-vaning occurs whether or not the missile is still under power.

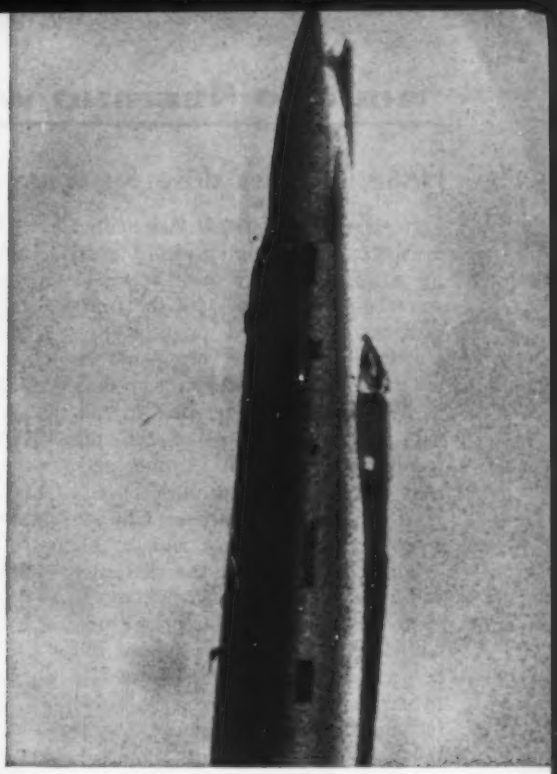
The gyro is said to offer many advantages. For one, tracking radar cannot predict the origin or destination of the missile. This is because it does not travel a straight line to the target. There is always at least one path to the target from the missile's instantaneous position. This path may or may not vary from launch position.

Also, the vehicles do not roll or spin regardless of firing conditions, tail fin alignment, wind velocity or direction, but no one on the Armour team has been able to explain why this is so. The fact has an important advantage: because the missile always maintains the same side facing the ground, warheads can be designed to direct all their energy toward the ground. By eliminating wasted energy, a warhead can produce greater ground damage than a conventional artillery shell.

Tests show the guidance system works provided it stays within the linearized mathematics used in its development—i.e., the rocket must not change course more than 10°, and the gyro-gimbal system must also operate within small angles. Accuracy of the system, now better than a free rocket, could be as accurate as rifle fire with refinements, its developers say.

—Bruce Cross, Chicago Bureau

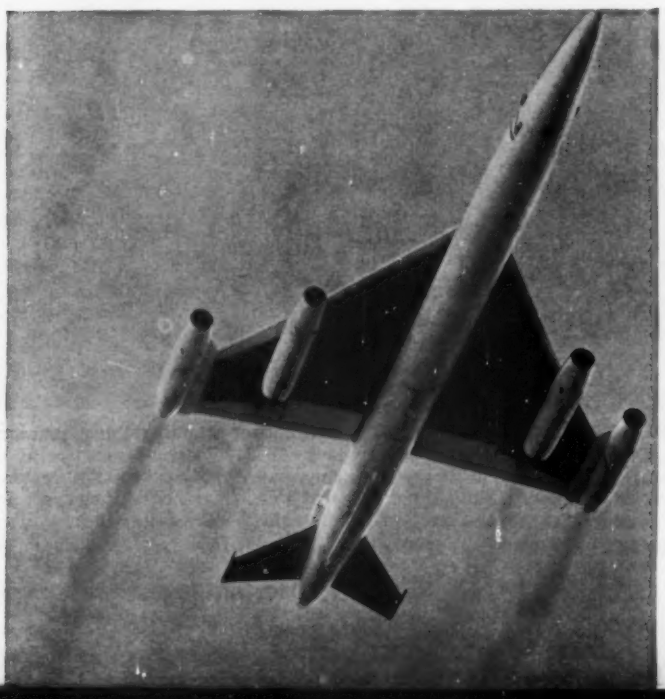


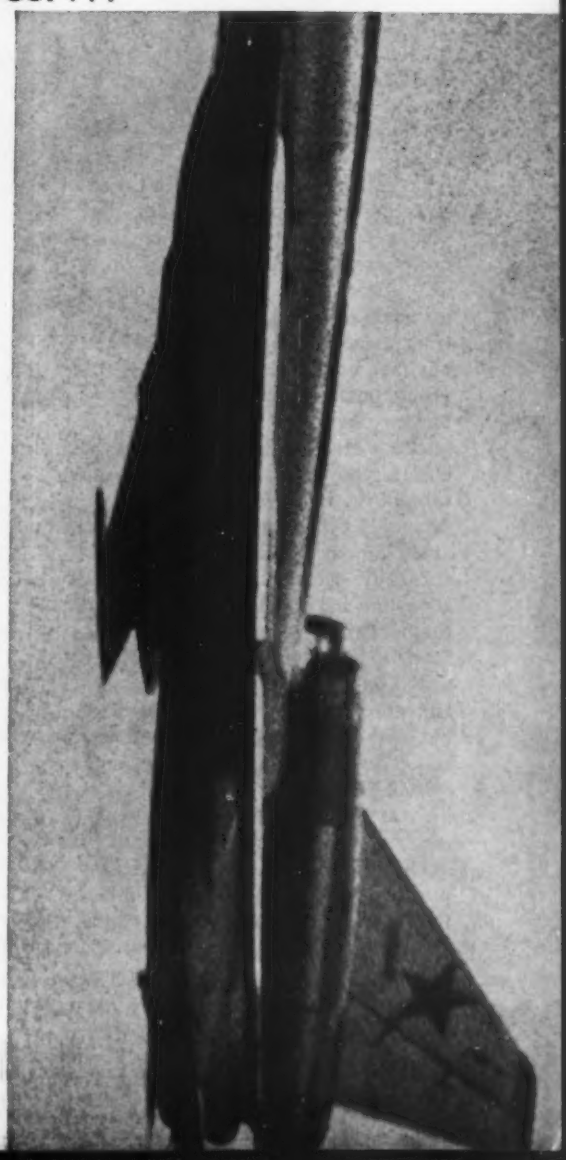


USSR fly-by impresses the West . . .

Russia paraded its aerial might at a big Moscow air show last week and reaction of Western observers was mixed. Some said the show was impressive, pointed up Russia's air might, and that large sums were still being spent for manned aircraft. Others felt that the planes were not new and were, in fact, carbon copies of US and British interceptors and bombers that are rapidly being obsoleted. Regardless, the show had great propaganda values and impressed a majority of the viewers.

Through the facilities of *Business Week* the following pictures were made available to PRODUCT ENGINEERING. They show, what many believe to be the newest in Soviet aircraft—interceptor (above), bombers (below and right), and convertiplane (top).





NASA launches drive for lunar engineers

CHICAGO—The National Aeronautics & Space Administration has kicked off a recruiting drive for scientists and engineers to work on the lunar program and related projects. Following in the path of many an industrial recruiter, NASA set up shop in a Chicago hotel recently to talk with anyone interested. Later, the recruiters went to visit 14 other midwest cities to interview prospects.

At a press conference in Chicago accompanied by much fanfare, Dr W. T. Olson, chief of the chemistry and energy conversion division at NASA's Lewis Research Center, Cleveland, said about 135 persons will be needed at Lewis by the end of July to start work on lunar projects. These include the Apollo, designed to orbit the moon; simulated lunar landings; the Saturn launch vehicle; Rover nuclear engine and other associated work.

If Congressional approval is granted to Kennedy's space program, about 2000 engineers and scientists will be needed to work in applied research, development and evaluation, Olson said.

Biggest needs are in mechanical engineering and applied physics, but "the people we want embrace practically every technology we can think of," Olson said. These technologies include chemical, electrical, electronics, mechanical, metallurgical and nuclear engineering; materials research, mathematics, metallurgy, and nuclear physics. R & D work on the nuclear rocket program, aimed at boosting the temperature of hydrogen to 4000 F, is one of the areas where personnel will be needed, Olson said.

He frankly admitted that the salaries NASA can offer beginners may lag as much as $800 to $1000 behind those offered in private industry, although "intermediate" range salaries would be competitive. Starting salaries for personnel with no experience but with bachelor's degrees will run about $6400, with doctorates, about $9000, Olson said. Salaries will go as high as $13,000 to $15,000, depending on experience and background.

Olson seemed hesitant to discuss precisely how NASA hoped to contact the desired personnel, beyond stimulating interest through the press and radio-tv. Someone jokingly suggested NASA "hang a sign on the door."

He shied away from any hint that NASA might try to "pirate" personnel from Chicago area companies. Contacts through engineering societies and universities will help stimulate interest, he said.

Because of the demand for qualified personnel and the salary differential, NASA has had to lower its standards for the people it wants, but not to the point where ineffective people will be hired, Olson insisted.

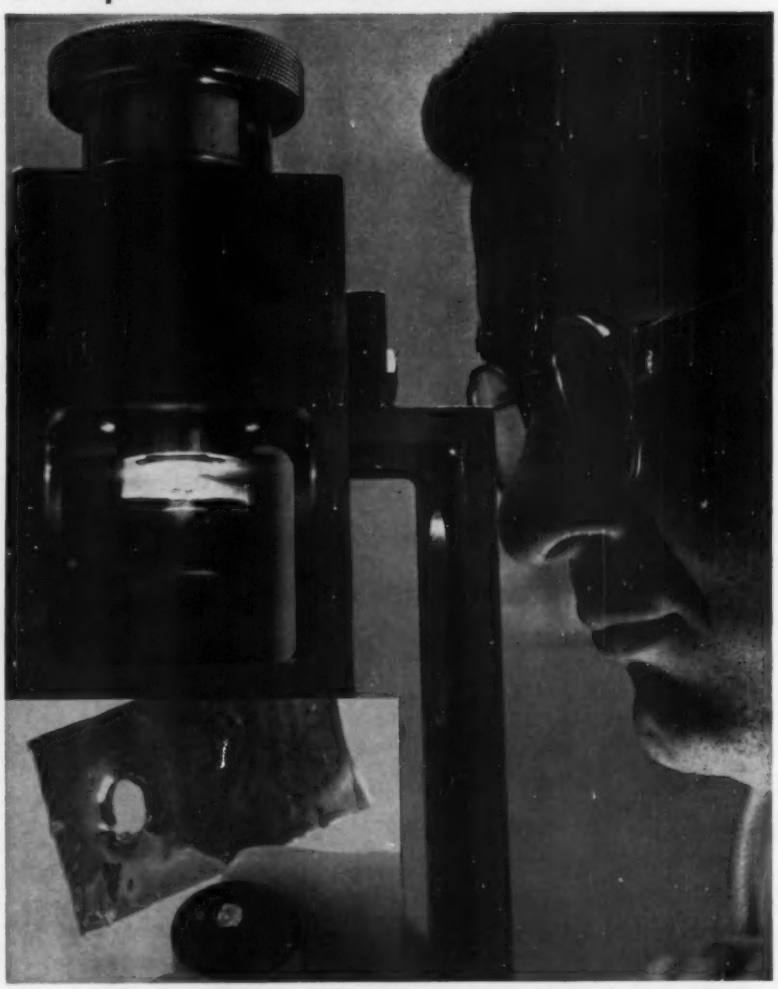
The Lewis center is NASA's space propulsion facility, but personnel to be recruited might also work at other NASA facilities in California, Maryland, Virginia, or Alabama, according to Olson.

Although the Chicago Conference was billed as "start" of the recruiting drive, Olson said similar meetings had recently been held also in New York and Boston. Some contacts with prospective employes were made, but no firm contracts yet signed, he added.

Recruiting on the West Coast probably will be handled mainly by NASA personnel located there, Olson said. He conceded there was some difficulty persuading people to leave the attractions offered by California.

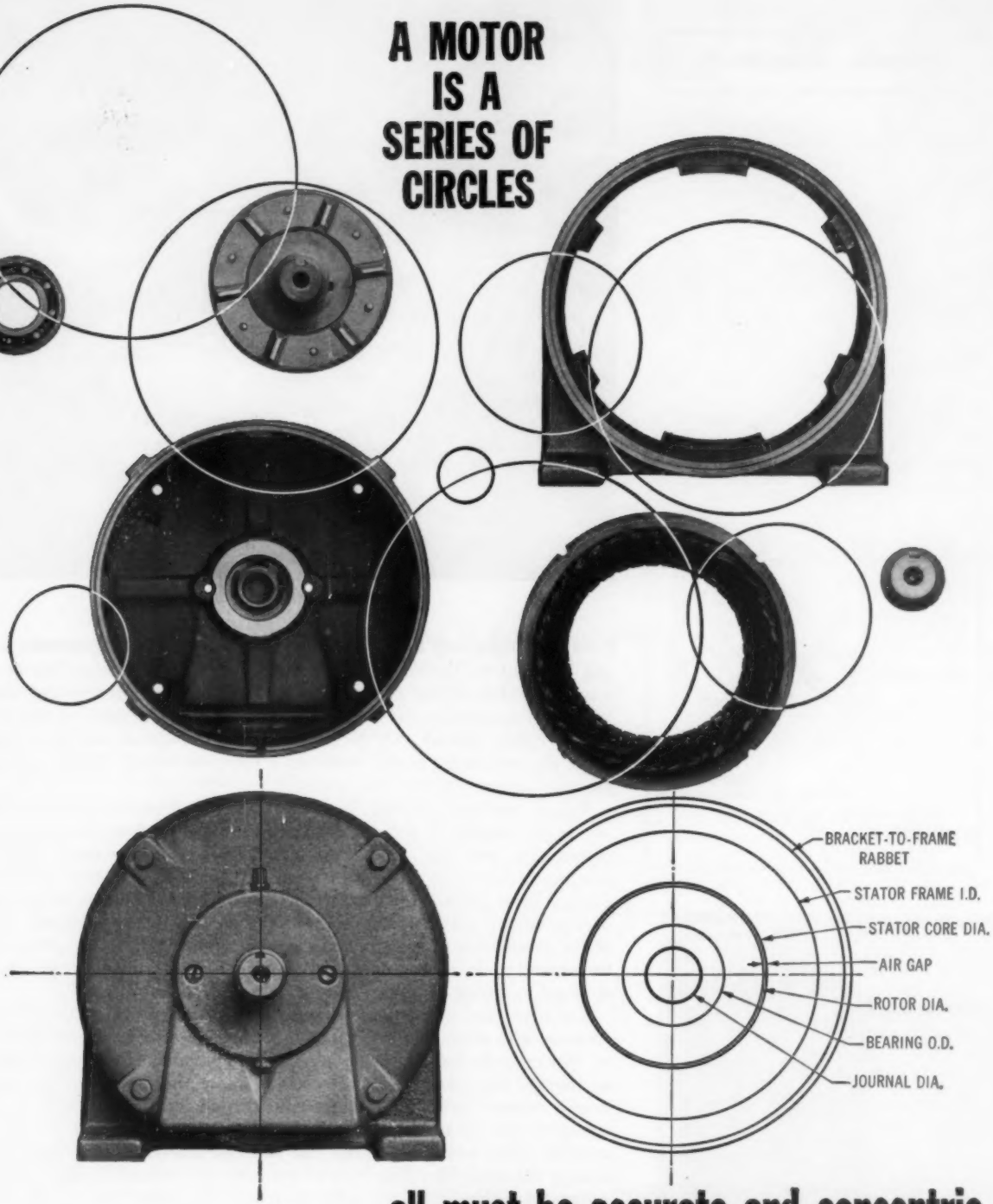
—Stewart Ramsey, Chicago Bureau

3400 mph water "bullets" dent steel



The brilliant flash of light is generated by the impact of a single drop of water, shot like a bullet into solid steel at speeds up to 3400 mph. Scientists at the Westinghouse research laboratories are using water "bullets" to study erosion, which occurs on turbine blades and the surfaces of high-speed aircraft and missiles. These single drops easily penetrate thin pieces of aluminum and can put sizeable dents in steel.

A MOTOR IS A SERIES OF CIRCLES



all must be accurate and concentric

In manufacturing Elliott Crocker-Wheeler motors, a dozen critical "circles" are formed accurately and concentrically through unique and extraordinarily precise production methods. The result is exact alignment of all parts, true and uniform air gap, free-spinning rotor, quiet, cool, dependable operation.

■ *Elliott Crocker-Wheeler integral-hp a-c and d-c motors—from smallest to largest—are offered in all conventional enclosures and modifications; with insulation to suit the application, including* EPA-SEAL *epoxy insulation for use where conditions are most severe.*

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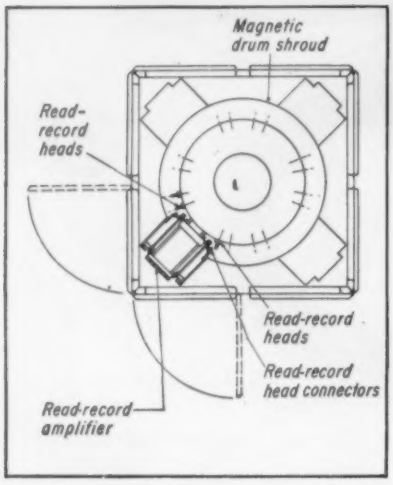
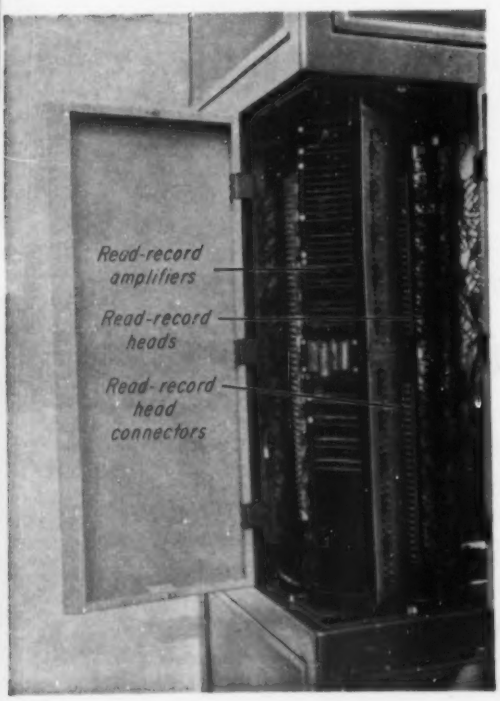
TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS • EJECTORS • STRAINERS • TUBE CLEANERS

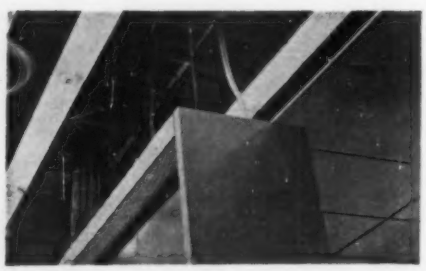


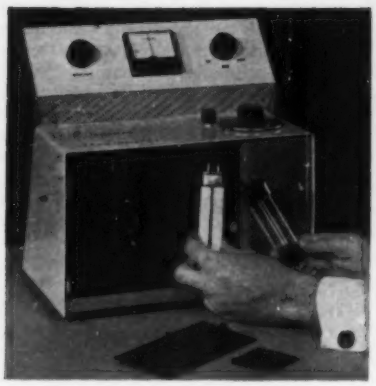
First completely automated demand-deposit system . . . was designed to handle increases in the number of savings and mortgage accounts held by savings banks. Difficulties in recruiting and retaining adequate tellers and accounting personnel were also important. Installed in the Howard Savings Bank, Newark, NJ, to service their six branches and main office, a single data-processing center maintains a complete record of each savings and mortgage account on magnetic drums.

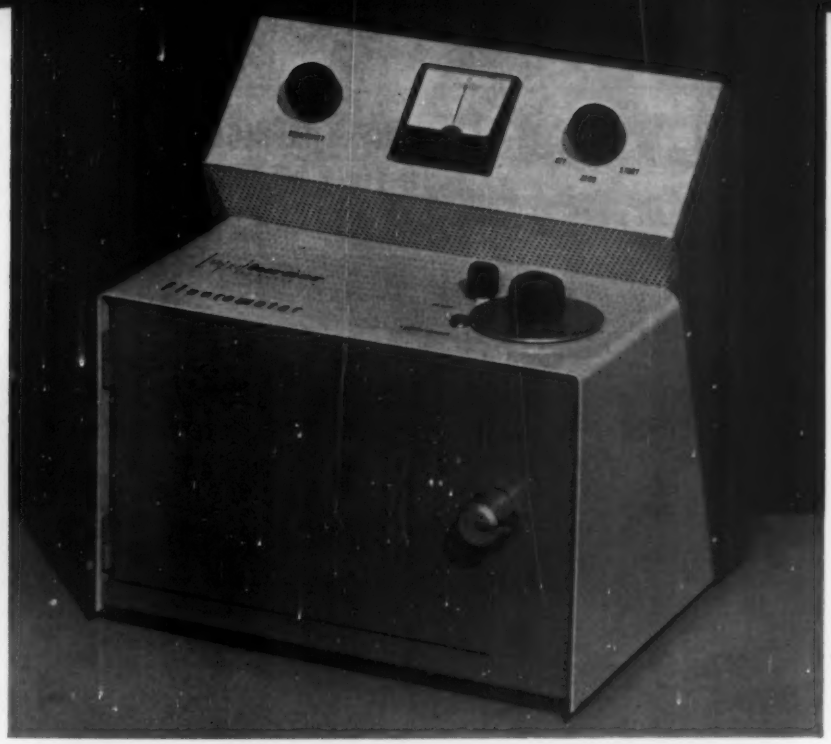
Called "on-line" posting, the teller need no longer leave his window to obtain the depositor's account card. Instead, the passbook is inserted in the proper slot, and the account number, amounts and necessary instructions entered by depressing the proper buttons. About 1½ sec after the "operate" bar has been pushed, the transaction is completed—including entry into the data-processing center's memory drum and posting in the passbook. Because of the elimination of the space-consuming, tub-like ledger files presently used for account cards, needed floor space is made available and fewer personnel are required to service depositors and maintain account records.

Cabinetry for the data-processing center consists of sheetmetal-sheathed framing, with doors that swing away for complete access. These cabinets are, in effect, ducts for conveying humidity-conditioned, temperature-controlled air through the system's banks of circuitry and electronic units. The magnetic drum's cabinet (left) has air-intake grilles on all four sides of its base, and is equipped with 16 muffin fans. Wiring and other supply lines used to interconnect a data-processing center like this can substantially increase building costs if the usual false floor is employed. At the Howard Savings installation, suspended ceilings (below, right) provided a simpler, less costly method. Manufactured by Teleregister Corp, Stamford, Conn. Industrial designer, Laird Covey, Monroe, Conn.





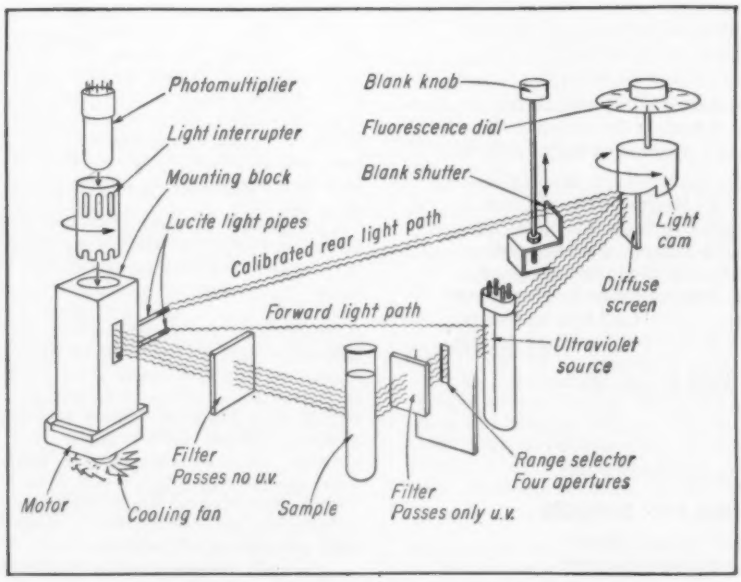




Fluorometer performs chemical analysis of fluids and solids . . . by measuring their fluorescence upon irradiation with ultraviolet light. Applicable to research, medicine and many technologies (including chemical, hydraulic and civil engineering). The instrument had to be capable of being used by itself—or with various types of accessories, recording equipment, assorted optical filters and conversion kits.

To provide optimum access and ease of placing and removing samples, sample holder was designed into vertical front panel. With this panel swung open (above, left) it is also possible to make most of the other necessary changes of accessories. Panel itself is interchangeable with others designed for such special purposes as paper chromatography, uranium ore assaying, continuous flow measurements. The relatively simple procedure for making repeated measurements of a series of samples can be carried out by unskilled operators, once the instrument is set up (all adjustments and calibrations are made inside the locked front panel).

Designed for short-run production, the only special tooling required is a spot-welding fixture for the sheet-metal housing components. All machined parts are wide tolerance. All circuitry is centralized in a single chassis. Made by G. K. Turner Assoc, Palo Alto, Calif. Industrial design by Gene F. Babcock, Santa Clara. —JK



HOW FLUOROMETER WORKS . . . Optical bridge measures the difference between light emitted by the sample and light from a calibrated source. The photomultiplier, surrounded by a mechanical light interrupter, sees light alternately from the sample and the rear light path. Its ac output permits the use of a drift-free ac amplifier for the first electronic stages. The second stage is a phase-sensitive detector whose output is positive if there is an excess of light in the forward (sample) or negative if the rear light path is stronger. Output of the phase detector drives amplifier which is in turn connected to a null meter. Equal light from the sample and from the rear light path produces balanced condition and is indicated by the null position of the meter. The quantity of light required in the rear path to balance that from the sample is indicated by the fluorescence dial. Each of this dial's 100 divisions adds equal increments of light to the rear path by means of a cam.

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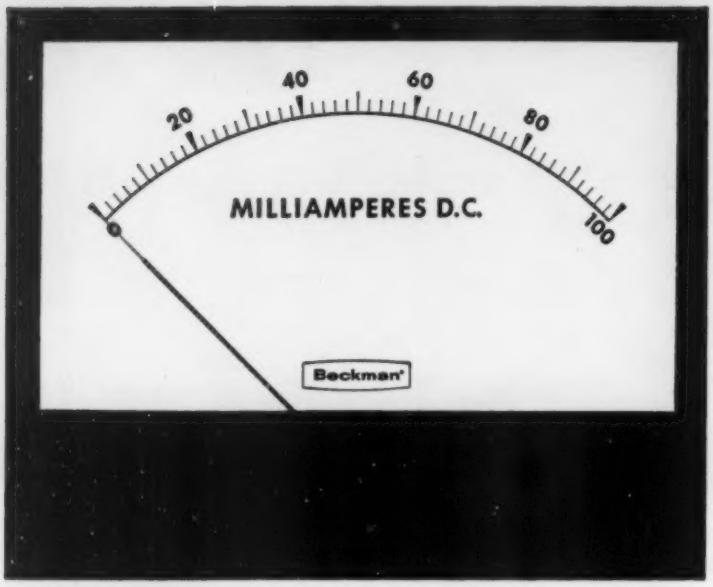
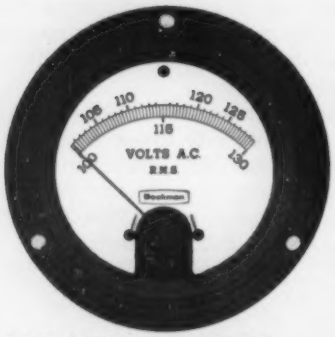


STANDARD PANEL METER
4" x 6" size, 0-100 Milliamps



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Beta ray indicator–4½"

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READER TO EDITOR

Wrong price quoted

To the Editor:

We appreciate your mentioning our fiber optics developments on page 24, of your June 12 issue. However, the prices quoted were in error. For example, the price of a 50-ft coherent bundle one inch in diameter was quoted at $1500. Coherent bundles of this size are custom-made items and we have not yet quoted prices for this size bundle. Bundles of that size would have only extremely specialized applications and the price would be considerable in excess of that quoted.—RALPH KAZARIAN
American Optical Co
Southbridge, Mass

• The price should have read: $1500 for a 5-ft coherent bundle.—Ed.

Thanks to WK^2

To the Editor:

Thanks to the lasting impression which John W. Harper's classic, "The Significance of Wk^2 and How to Calculate It" (June 27, 1960), made on me I was able to spot quickly the omission of a potentially important power of 2 in the formula for equivalent moment of inertia in John Proctor's comprehensive article, "Selecting Clutches for Mechanical Drives" (June 19, p 43). A second error in the formula as printed, a U in place of the second W, is obviously a typographical slip.

The formula, on page 44, should read:

$$WK_e^2 = WK_a^2 \left(\frac{\text{rpm } a}{\text{rpm } c}\right)^2$$

—EVERETT CLEMENT
Staff Consultant
New Hampshire Ball Bearings Inc
Peterborough, N H

• Mr. Clement is right. We caught both errors in time to correct them on the reprints which are now available.—Ed.

Strength in glass

To the Editor:

I noted with interest a report in the "Whats New in Research" section (May 22, p 6). Specifically the subject dealt with test liquids causing delayed strength loss and fracture of steel chambers. The article suggests some theories advanced by the Naval Research Laboratory, one of which appears to be related to a condition found in testing glass for stress and strain.

The strength of most glass lies in its surface and when a newly formed glass sample with unblemished surface is subjected to atmospheric moisture abrasion, contaminants, etc., there is a radical drop in strength of the sample. One of the techniques used for analyzing or approximating the degree of tensile strain present in glass articles consists of scratching the surface in a suspected tension area, and applying a liquid such as water to the abrasion. In areas where tension is very high, spontaneous failure occurs from the scratch alone, without liquid being present. Atmospheric moisture apparently serves to assist propagation of the failure.

When the level of tensile stress is some-

what lower, accelerated results are obtained by liquid immersion of scratched samples. For example, an area of tensile stress scratched lightly with a diamond point might require hours to fail. Submerged in liquid, the same failure might require only minutes. It has been theorized that the liquid forces its way into the scratch and accelerates failure.

I suggest that surface dissimilarities and irregularities, coupled with a strain condition in the material, can be partly responsible for the observed failure of the steel chamber—especially when coupled with moisture attack. Some irregulariites may already be present in the form of "micro checks" in the steel surface, others might be caused by surface handling and treatment during installation. A simple test could be devised whereby samples of the material could be treated, immediately after forming, with a surface coating to prevent attack by moisture and abrasion. Fracture strength could then be compared to untreated samples. There is some evidence that surface treatment of glass in the form of protective coatings lends "apparent" strength increases. In reality, observed results may instead, point to the prevention of strength deterioration through surface attack.—JAMES H GRAY
Painted Post, N Y

COMING EVENTS

AUGUST

22-25 . . . . Institute of Radio Engineers, WESCON Electronic Show & Convention, The Cow Palace, San Francisco

23-25 . . . . American Institute of Electrical Engineers, Pacific General Meeting, Salt Lake City, Utah

28-Sept 1 . . . . American Society of Mechanical Engineers and American Institute of Chemical Engineers; Institute of Mechanical Engineers and Institution of Chemical Engineers (Great Britain), International Heat Transfer Conference, Univ of Colorado, Boulder

SEPTEMBER

11-14 . . . . Society of Automotive Engineers, National Farm Construction & Industrial Machinery Meeting, Milwaukee Auditorium, Milwaukee, Wisc

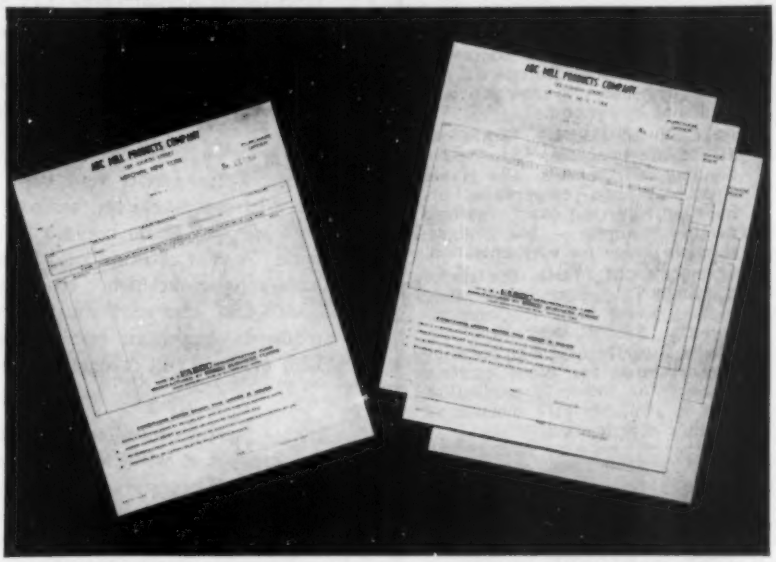
14-15 . . . . American Society of Mechanical Engineers, AIEE and IRE, Joint Societies Engineering Management Conference, Hotel Roosevelt, NYC

20-21 . . . . Institute of Radio Engineers, AIEE and ISA, Industrial Electronics Symposium, Bradford Hotel, Boston

25-28 . . . . American Welding Society, Fall Meeting, Adolphus Hotel, Dallas, Texas

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R- 32.

DRAFTING TRENDS



See how little difference can be noted between a nearly opaque original (left) and three fast, economical diazo copies (right) made with POST Super Vapo Black Paper.

New Super Diazo Papers Make Prints From Prints

More uses—
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The convenience and versatility of the whiteprinting process takes on new meaning with these important POST developments. Available in sheets and rolls as Super Veri-Blac (440-14) for semi-moist diazo equipment, and as Super Vapo Blue (206M-14) and Super Vapo Black (208M-14) for dry, ammonia-process machines.

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Cost is a key word in the consideration of any new product. POST Super Diazo Papers cost no more. Further, both large and small users will be quick to note that the combination of speed and economy basic to these new diazotype papers make them practical for longer runs—even 50 copies—and, less expensive than other duplicating methods often selected for such quantities.

Ask your POST dealer or write Frederick Post Company, 3642 North Avondale Avenue, Chicago 18, Illinois, for Super Diazo Facts.

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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

CIRCLE 23 ON READER SERVICE CARD

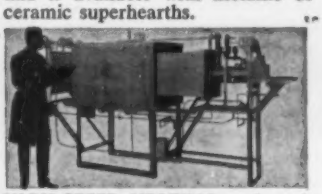
Ed Johnson, Furnace Application Engineer, talks about

SINTERING STAINLESS

Whether you're working with cermets, ceramics, refractory metals, or stainless steel powder compacts, Hayes has the *right* furnace and the *right* atmosphere to give you best results at lowest cost.

PRECISE SINTERING TEMPERATURES are important for effective bonding of compacts. The Hayes Type M-Y High-Temperature Furnace provides the exact, uniform heating required — has straight-through design for easy operation.

ECONOMICAL, TOO, the Hayes Type M-Y furnace needs only modest power input for temperatures to 3300°F with Moly elements. It can be used with reducing atmospheres for close control research or full-scale production, and is available with metallic or ceramic superhearths.



HIGH-SPEED HEATING and cooling cycles mean big production with the Hayes Model HT/HV Vacuum Furnace. A full-production size vacuum furnace, this Hayes unit is cold-wall designed for compactness as well as operating comfort. Heat-up to 3000°F range and over in minutes, with low voltage elements. High vacuum to 0.1 micron . . . low leak rate.

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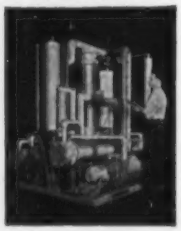

WHATEVER YOUR SINTERING PROBLEM — for production, high temperature or research sintering, Hayes know-how and equipment can supply you with a Results Guaranteed answer . . . tested in our lab on shop-scale equipment, and proved by scores of similar installations in industry. Write for bulletins on Hayes sintering furnaces. C. I. Hayes, Inc., 958 Wellington Ave., Cranston 10, R.I.

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WHY DON'T THEY R&D..?

The following problems are drawn from a list of 87 new problems in the most recent edition (June '61) of the government publication, "Inventions Wanted by the Armed Forces and Other Governmental Agencies." Copies are available free from US Department of Commerce, National Inventors Council, Washington 25, DC. An introduction to the booklet tells where to send proposed solutions and how they will be handled.

. . . a zero-gravity vent valve that will distinguish between liquid and gas. In space vehicles, ordinary vent valves in propellant tanks will vent both gas and liquid because liquid does not remain in the bottom of the tank. A vent of some kind is needed because the low-temperature propellants vaporize at higher temperatures and create excessive pressure in the tank. But the vent must prevent escape of the precious fuel. The required valve must operate for prolonged periods under conditions of high vacuum and cryogenic temperatures.

. . . a pressure transducer sensitive to pressures in the 0 to 25 psia range but capable of withstanding overpressures to 1000 psia. In testing rocket engines it is necessary to measure pressure decay in the combustion chamber during the period immediately after fuel shut-off. When the engine is running, chamber pressures range between several hundred and 1000 psia and for this reason, transducers calibrated over this range have been used to measure the decay pressures. But they are inaccurate at the low tail-off pressures. One hundred psia transducers with stops have been tried but they are not as sensitive as transducers designed specifically for the low-pressure range. The required transducer must have frequency response to 1000 cps and be designed so that it can be mounted flush with the chamber wall.

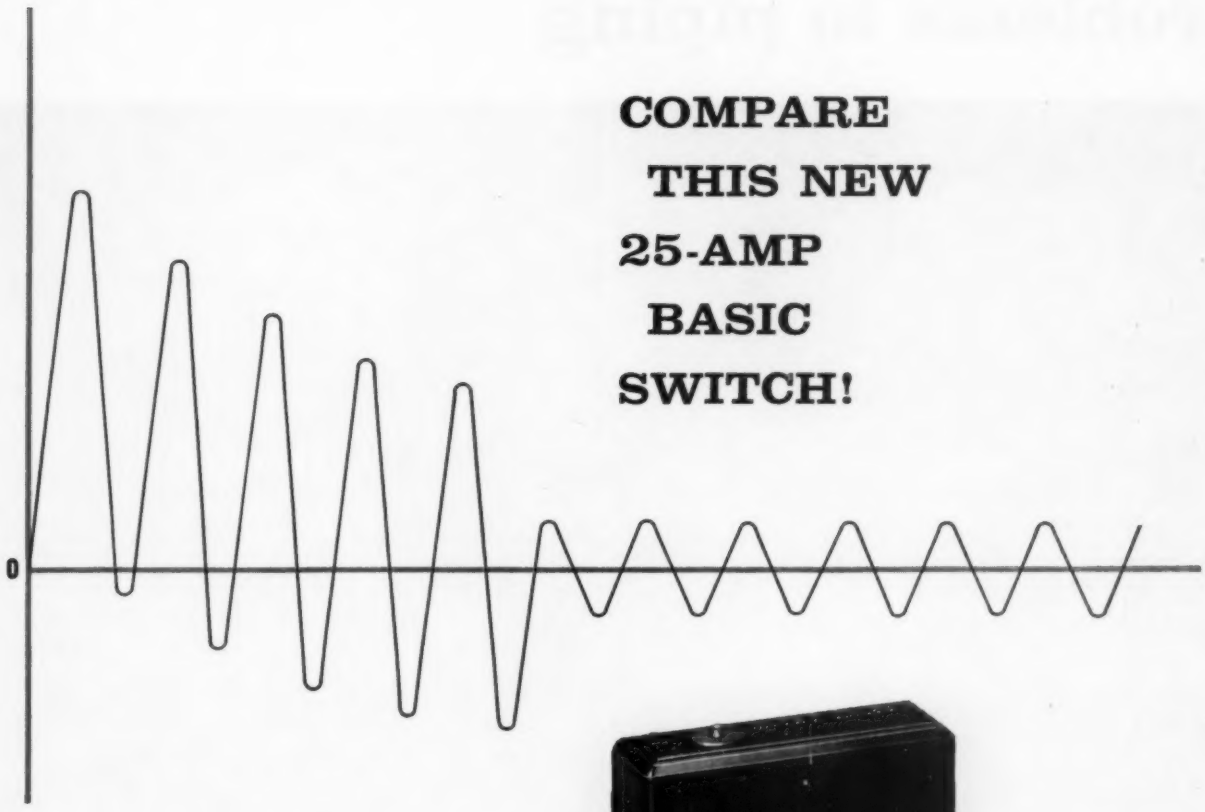
. . . a simpler digital-readout, mercury barometer. The present servomechanism system, which follows the mercury column as it rises and falls, costs between $3000 and $8000 depending on complexity and reliability. The required simpler system can be either mechanical or electrical but must read the barometer correctly to ±0.002 in. of mercury.

. . . an inexpensive chemical that could be mixed with seawater to precipitate the dissolved sodium chloride. If practical, this method would be much superior in all respects to distillation or electrolysis, now the chief means for desalting seawater.

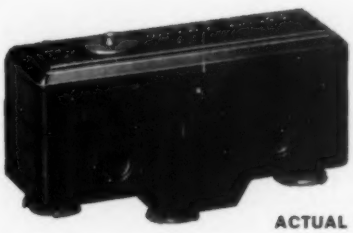
. . . a repellant to keep birds off the rails of high-speed, rocket-sled tracks. The birds have been known to penetrate steel plate and do much damage to the sleds. They are attracted by the water tank used for high-speed braking and they roost on the rails because of their preference for elevated structures. Test personnel have tried playing startling noises over the warning system, including hawk calls, cat meows, snake hisses, bear growls, lion roars, Comanche war whoops, gunfire, and most of the blood-curdling noises made by man or beast that can be recorded. But the birds soon accustom themselves to the noises and refuse to scare. Chemical bird repellants cannot be smeared on the rail without affecting the performance of the sled and if applied nearby, will not keep birds off the rail.

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with readers who have a fresh viewpoint or more time to experiment. We pay $10 on acceptance.

MICRO SWITCH Precision Switches



COMPARE THIS NEW 25-AMP BASIC SWITCH!



ACTUAL SIZE

Handles inrush currents up to 75 amps!

Now! A new series of MICRO SWITCH basic switches with a higher current rating. The Type "E" series features a steady state current rating of 25 amperes with accurate repeatability and precision performance. Designed for the many new applications where higher capacity is needed for snap-action switches of conventional size. Contact arrangement is single-pole double-throw. Heavy-duty screw terminals. See the Yellow Pages for your nearby MICRO SWITCH branch office or write for Data Sheet 181.

Underwriters' Listing

The new Type "E" Basics are listed by Underwriters' Laboratories at 25 amps—125, 250 and 480 vac; 1 hp—125 vac; 2 hp—250 vac; Pilot Duty: 750 VA—125, 250 vac.

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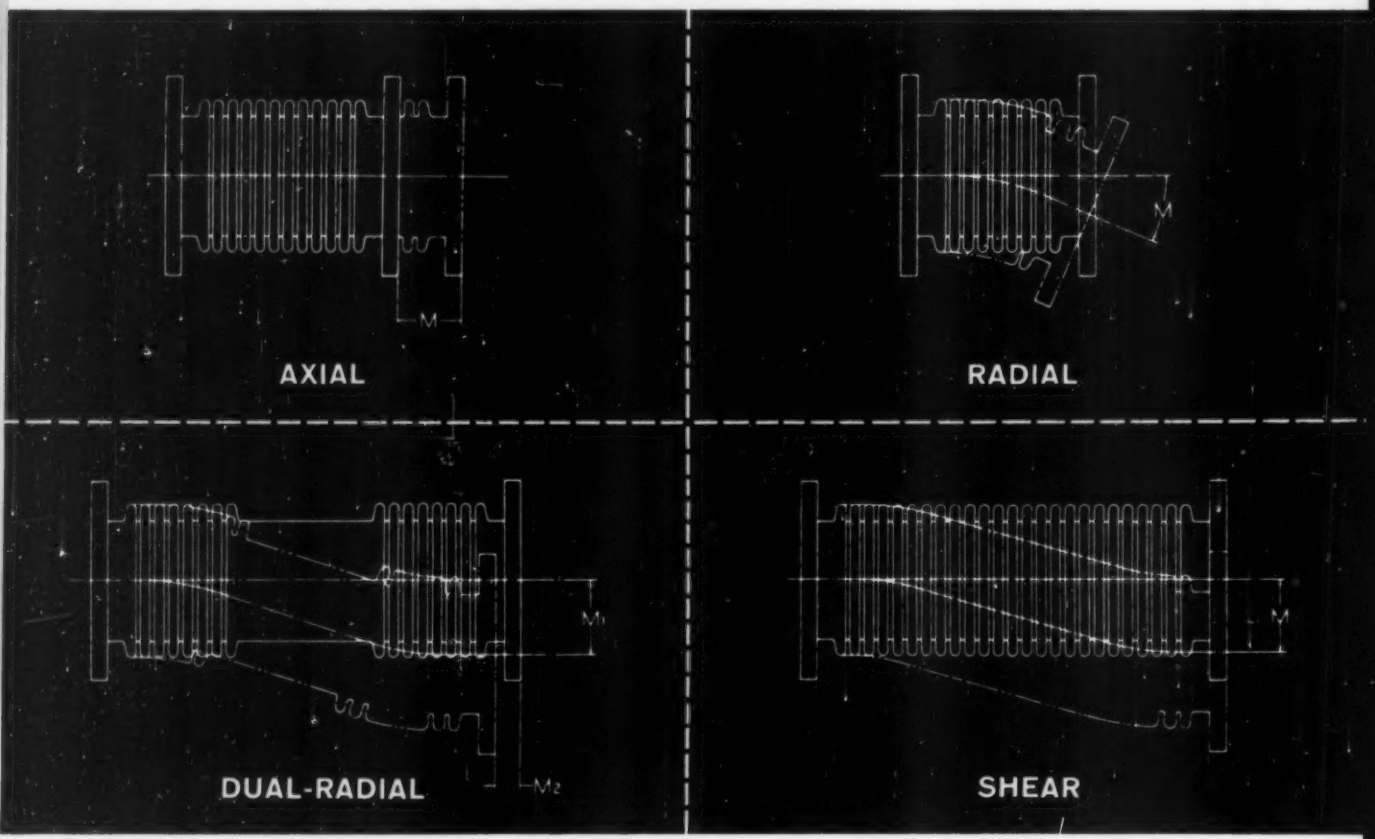
A-X, Anaconda's flexible tubing, solves a variety of tough movement problems in piping

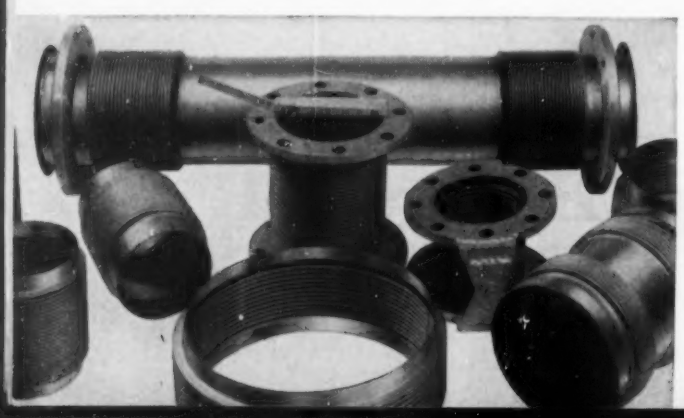


Expansion and contraction. Lateral movement. Misaligned outlets. A-X tubing is specially designed to handle tough problems in large piping used to convey liquids or gases.

A-X* tubing is available in Bronze, Stainless Steel, and other metals and alloys—from 4½" I.D. to 14" I.D. —complete with end fittings.

Bulletin A-X 97 gives complete details. Call your Anaconda Metal Hose representative for a copy—or for the services of an Anaconda specialist to help you in the design of a special connector to meet your needs. Or mail the handy coupon below.

*Trademark 61131



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A Matter of Orbits

Back in 1300 BC, an obscure little tribe in Asia Minor learned how to smelt good iron by boosting working temperature from 1000 to 2000 C. The Hittites exploited the idea and overturned four kingdoms, including mighty Egypt. Only now is Egypt showing signs of recovery, even though the Hittites have long since disappeared.

With that breakthrough, the Hittites expanded their orbit—just as we are doing now, with a man making a controlled flight at 3700 mph and one going into space at five times that speed. But we must be able to exploit every breakthrough if we are to stay pre-eminent.

In this light, some figures published recently by *Business Week* are disquieting. They are in terms of index figures based on 1953, and show that our prices of manufactured products have risen faster than in other major countries. Even with a relatively slow rise in wages since 1953, rise in labor cost per unit manufactured is second only to that of England. While the responsibility for this situation is commonly assessed to labor rates, our total hourly wage has shown the lowest rise of any major country. (It should be remembered, of course that our wages were far higher initially, so that the higher rates of increase elsewhere still leave us with the highest labor costs in the world.)

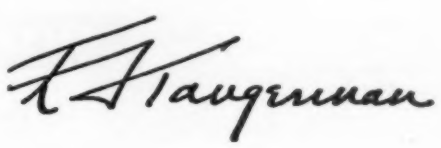
The crucial figures are not there, but in the column headed "Productivity"—the output per manhour in manufacturing—our rise is far below any other. Again some of the difference is in a higher base, but our rate of gain is still too slow. While we gained 15% in seven years, England went up 29%, Germany 53%, France 54%, Italy 58% and Japan 71%. And the productivity gain in our major export items—heavy manufactures (machinery, electrical equipment, vehicles) and materials—is lower than the average relative to wage increases.

Every economist has a different explanation of the figures, as well as a different prediction of their effects. It seems to us, however, that the numbers emphasize three factors of importance:

1. We need new designs that increase productivity.
2. We need to replace low-productivity equipment.
3. We need a rebirth of the idea of "a day's work for a day's pay"—an idea that has been losing ground here while gaining elsewhere.

	Prices Mfd* Products	Share of World Mkt, %	Trend	Labor Cost Per Unit*	Total Hourly Wage*	Productivity*
US	116	21.9	—	114	131	115
UK	110	16.7	—	124	160	129
W GERMANY	105	18.6	+	110	169	153
FRANCE	95	10.1	+	87	134	154
JAPAN	—	6.7	+	85	149	171
ITALY	—	5.2	+	92	145	158

*1953=100



How to get a pump and motor into the smallest possible space

by E. H. Schanzlin
Chief Engineer, Tuthill Pump Company

Today's designer faces stringent limitations on space and weight in more and more of his assignments. Miniaturization is the order of the day. Even if we exclude rockets, missiles, aircraft and similar applications, reducing the size and weight of pump and motor combinations can result in significant savings.

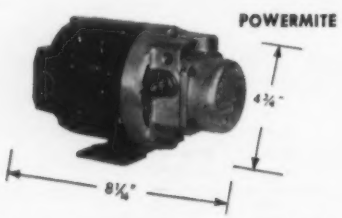
Compactness simplifies assembly operations . . . lowers production costs. Reduced weight means lower shipping expense. Elimination of components such as couplings, bases and adapters can mean substantial savings. And often a compact unit can provide the only feasible answer to a tough design problem.

Special Combinations Developed

Five years ago, Tuthill's engineering department initiated a special program to develop compact pump and motor combinations to provide the greatest possible savings in space and weight. The units on this page, plus others in our stock and on the drawing boards, are a result of this intensive and continuing program.

Powermite for OEM

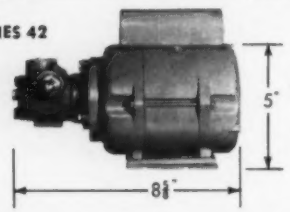
For original equipment applications involving substantial quantities, Tuthill's engineers have developed a special design in which the pump and motor are combined in one unit which takes up no more space and



weighs no more than a standard electric motor. The typical Powermite above, used in a hydraulic application, has a capacity of 16 gph at 350 psi despite its small size. Each Powermite is specially designed to meet the exact requirements of a specific OEM application.

Standard Units from Stock

In addition, Tuthill provides a wide selection of standard combinations immediately available from stock. Unlike the Powermite, the stock combinations can be furnished in single units, or any desired quantity.



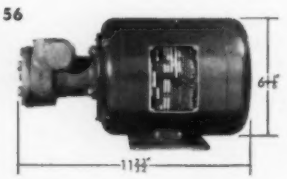
Here is a typical combination . . . series 42 totally enclosed ball bearing motors supplied with ratings from 1/12 to 1/6 hp, in combination with pumps with capacities of 20 to 45 gph at pressures to 200 psi.

Series 48 Combinations

A selection of series 48 combinations are normally supplied with totally enclosed fan-cooled motors of either split phase, capacitor or 3 phase construction, with ratings from ¼ to ½ hp. Pumps supplied in these combinations range from 20 gph to 360 gph at pressures to 360 psi. A typical combination measures only $7\frac{5}{8}$" x $10\frac{7}{16}$".

Series 56 Units Available

Series 56 units measure $6\frac{11}{16}$" x $11\frac{23}{32}$" as shown. They are offered in a complete range of motors from ¼ to 1 hp . . . which can be coupled with pumps with capacities from 20 to 360 gph at pressures to 500 psi.



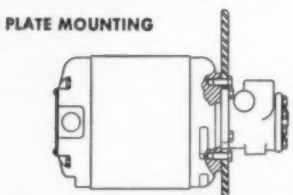
Many Others Available

Many other pump and motor combinations are available with capacities up to 50 gpm and for pressures to 500 psi. A new selection of closed coupled units will soon be offered with motor ratings to 5 hp.

Motors are normally furnished for 1725 rpm. However, they are usually available for 3450 and 1140 rpm as well. Explosion proof construction and double shaft extensions on motors are also furnished. Built-in relief valves and other modifications are optional.

Special Flange for Plate Mounting

For many applications a special mounting for close-coupled pump-motor combinations offers distinct advantages. Shown below, it allows the pump and motor to be mounted on any plate of sufficient thickness to bear the weight of the unit, by simply cutting a circular hole of sufficient size to allow the passage of the pump. It is particularly convenient for mounting on tanks, where it greatly simplifies piping arrangements. Through elimination of mounting flanges it further reduces space and weight.



Send Us Your Problem

In addition to these, Tuthill has developed a wide range of solutions to special problems involving pump-motor combinations. If you are trying to fit a pump and motor into a small space, take advantage of our experience. Write and give us the details.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm.

PUMPS FOR YOUR PURPOSE
TUTHILL PUMP COMPANY
963 East 95th Street, Chicago 19, Illinois

PRODUCT ENGINEERING

MECHANICAL COUNTERS FOR SPEED— AND ECONOMY

What kinds are available in the range, 1000 to 3000 rpm? What are their strengths and weaknesses? Which is best for you: plastic or metal? How about Geneva transfers —yes or no? And are ball bearings worth the money? This report helps you decide.

BRUCE H FRISCH, *assistant editor*

■ In this electronic age the mechanical counter is still the cheapest way to get digital readout up to 3000-rpm input. Only beyond that, where mechanical counters don't hold together long anyway, do prices approach those for electrical and electronic counters.

Its simplicity and compactness give the mechanical counter its competitive edge. Even at its higher speeds, over 1000 rpm, it comes in three basic designs that are simple, tried and true. One is all-metal, good up to 1200 rpm. The second has plastic wheels and pinions. It can go as fast as 2500 rpm—as can the third, which is all-metal and with a Geneva transfer between the first and second wheels. Limited to the three designs, you must solve the special problems of speed, torque and dimensional stability. You do this with design refinements and careful selection of materials.

COMPARISON OF COUNTER MECHANISMS

Mechanically, the three basic designs boil down to two ways of transferring motion from one wheel to the next—by external pinion or by Geneva wheel. If you need reset, that introduces two more versions. And then there is a fifth special case. Here are the inherent weaknesses and strengths of the five versions.

External-pinion counter

High impact when the transfer tooth hits the pinion is the drawback of the external-pinion counter at high speeds. The result is harmful wear of two kinds.

(1) Wear of the transfer tooth and the pinion gear teeth. At the first transfer, where the most impacts occur, the pinion wears the most; the transfer tooth, $\frac{1}{2}$ to $\frac{3}{4}$ as much.

(2) Wear at the locking surface. During each transfer the pinion whips around into the locking surface, eventually scalloping it.

Final failure from the combined wear comes when the gears mismatch so much that the pinion shaft bows and the gears jump out of mesh. Wear particles may obscure the readout figures shortly before total failure.

Although wear from impact is the main cause, failure can be hastened by vibration—internal or external.

Normal internal vibrations are negligible, but if the counter runs at harmonic speed, the pinion rebounds from the locking surface just in time for the next transfer. This resonance can build normal vibrations to amplitudes that shake the gears out of mesh.

The remedy is to destroy the resonance by changing the masses and diameters of wheels and pinions, and the stiffness of the shafts.

External vibrations can make the pinion rub on the locking surface, thereby accelerating scalloping.

Geneva transfer

A Geneva transfer reduces impact, because instead of a collision between the transfer tooth and pinion, there is a gradual and controlled acceleration. And the entire transfer procedure takes twice as long—over a 72° rotation of the first wheel compared with 36° for a straight external-pinion counter.

Thus there is a penalty of greater ambiguity. If a two-

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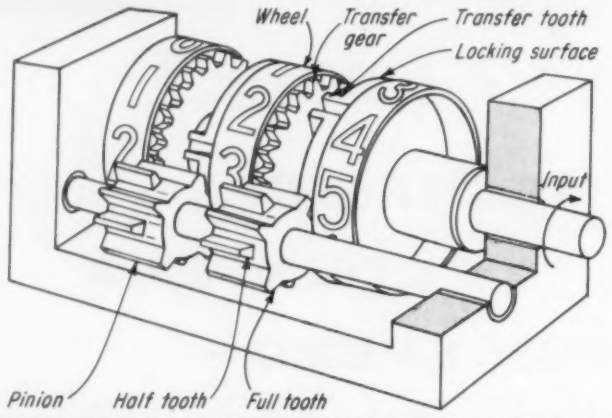
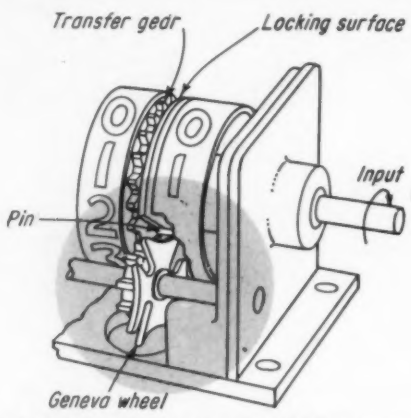


EXTERNAL PINION COUNTER carries the numbered wheels on one shaft, the pinions on a countershaft. The first wheel is direct drive; the rest driven by the pinions. Once per revolution, the transfer tooth (kicker) on the first wheel picks up a full tooth on the first pinion, and turns the second wheel one number. When the next full tooth hits the locking surface, the pinion stops. Until the next transfer the pinion cradles the first wheel between two successive full teeth, locking itself and the second wheel. Because of this locking method, accumulation of tolerances misaligns each number slightly more than the preceding one. If tolerances are too large, the numbers spiral.

The pinion rotates the second wheel one number while the first wheel turns 36°. Thus, if a 2-wheel counter reads 09, it changes to 10 between 9.5 and 10.5 Start and finish of a transfer can be shifted about, though still taking place over 36° rotation. For instance, one manufacturer designs his counter to transfer between 9.0 and 10.0; another has the transfer occur between 9.1 and 10.1.



MODIFIED GENEVA TRANSFER turns second wheel one number while the first turns 72° whereas standard 4-slot Geneva wheel turns 90° while the driver turns 90° (with both methods, pin on first wheel slides in and out of slot as it turns the Geneva wheel). Unlike usual Geneva transfer, modified version does not lock with its cutout against the first wheel. Instead, the pinion locks as in the external-pinion type. This way, diameter of the locking surface is larger and positioning more accurate.

wheel counter with a Geneva transfer reads 09, it will change to 10 between 09 and 11. This is more confusing to read than an external-pinion transfer, which changes between 09.5 and 10.5. As with the external-pinion transfer, suppliers shift the beginning and ending of the transfer. One make transfers between 8.5 and 10.5.

Although eliminating a weak spot, the Geneva transfer has one of its own. During transfers the pin slides in and out of the slot in the Geneva wheel. This sliding friction, combined with side loads as the pin accelerates and decelerates the Geneva wheel, wears the pin into a triangle.

Reset by moving shell

A moving shell has two limitations: low speed and irreversibility. At high speeds the inner part of the wheel races ahead of the shell and loses an accurate count. Because of the inertia of the shell, the spring-loaded pawls slip from slot to slot. Increasing the spring force raises the speed at which racing starts, but makes resetting harder. There is no remedy for irreversibility short of complete redesign to eliminate the unidirectional key. Usually no one bothers to go so far as complete redesign. Instead, they switch to:

Reset by heart-shape cam

This cam can reverse and doesn't limit speed. Except for the cam itself, all the reset mechanism is separate and doesn't interfere with the normal counting of a standard counter. However, the added mechanism increases both size and cost.

Special—the corrected reading counter

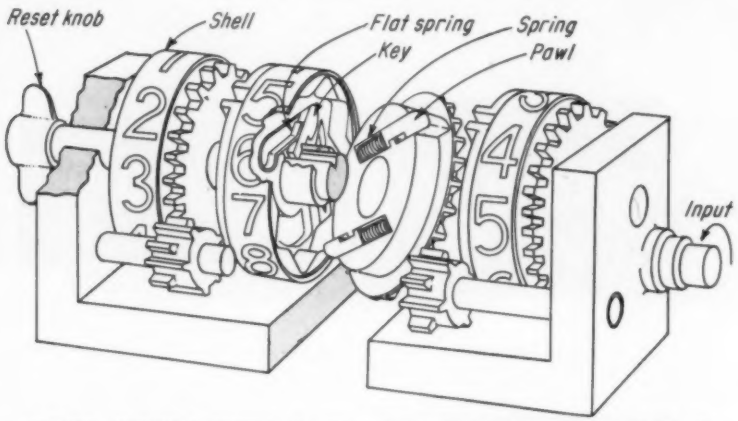
Besides the four main versions, there is one counter in a class by itself. It is bigger, more complicated and more expensive, but it can hit speeds of 6000 rpm. To get around the problem of high-speed transfer it just doesn't use a transfer on the first wheel. Instead, at 120 rpm, it shifts to direct 10:1 gearing. When the counter stops, the second wheel may sit anywhere between numbers, making it hard to read. A solenoid or mechanical pull turns the second wheel back to the previous digit so it reads just as it would if it had a standard transfer.

The first real transfer idles along at 500 rpm. Impact is as high as for 5000 rpm, but it occurs less often.

SPECIAL REQUIREMENTS

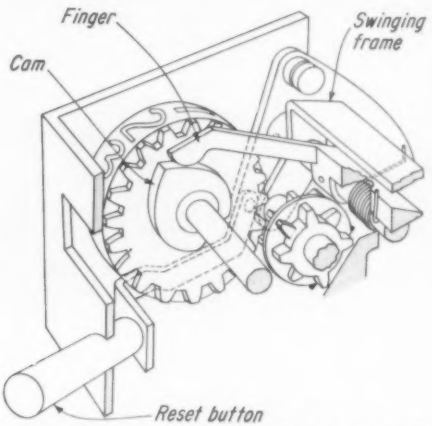
High speed

Be alert when you are studying claims for counters. Like horsepower in automobiles, rpm in counters has tricky meanings. The kind of rpm that is most common and most meaningful is when there is direct drive to the first wheel—which makes one transfer per revolution to the second wheel. Use this as a standard. For instance, a company may claim its counter operates at a phenomenal-sounding 4000 rpm. However, this may mean only 400



RESET, MOVING SHELL is separate part of wheel. Other half of wheel which carries the transfer gear drives the shell through spring-loaded pawls. Except during reset, wheel-shaft does not turn; therefore, input to first wheel must be through gearing.

At the start of count, with a zero reading, all keys sit in the keyway. Movement of wheels drags them out. During reset, the shells move and transfer gears stand still. A single turn of the wheel-shaft drops all keys back into the keyway; then a slight additional turn brings up all zeros.



RESET, HEART-SHAPE CAM has steadily decreasing radius from point to cleft. Thus the pressing fingers always turn wheels cleft upward so that zeros face out the window.

The swinging frame that carries pinions is linked to fingers by springs. When a push of the reset button forces down the fingers, springs swing the frame, disengaging the pinions. Center disks keep pinions aligned during the reset cycle. Counting method is same as for an ordinary external pinion counter.

rpm because there is a 10:1 gear reduction to the first wheel.

Rpm is only half of the story. No rating is complete without the second half—life. Two counters may be rated for the same maximum continuous speed, but for different life spans. Catalog ratings can only be a rough guide. After learning of your specific application, the manufacturer will probably want to alter slightly the rating or the design.

While the user may blame the manufacturer for short-lived counters, it is the user who often brings premature failures upon himself. The major complaint by countermakers is against the designer who ups the speed of his machine without considering the counter. Also criticized is buying a counter for a specific speed, when what actually is meant is average speed—the counter fails when it has to run momentarily at the higher peak speeds.

Almost the only limit on speed and life is the wear caused by that punishing impact during transfer. One way to reduce impact is to cut weight, and one way to cut weight is to make the wheels smaller. For example, one manufacturer reduces the diameter of a Delrin plastic wheel from 1 in. to ¾ in., and thereby drops the weight 56%, from 5.1 gm to 2.25 gm.

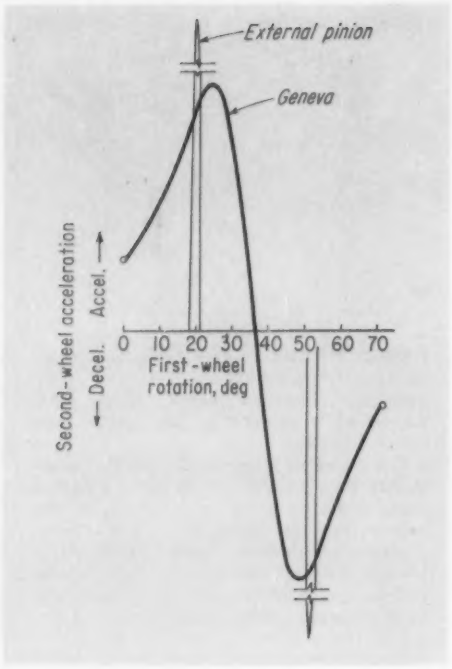
The three standard wheel diameters are 1, ¾ and ½ in. For each drop in size there is approximately a 25% gain in maximum speed. The ideal size is from 0.500 to 0.687 in., which balances minimum weight against adequate cross-section to withstand impact. So there is no advantage in going below ½ in. dia. Miniature and subminiature counters suffer also from tolerance problems.

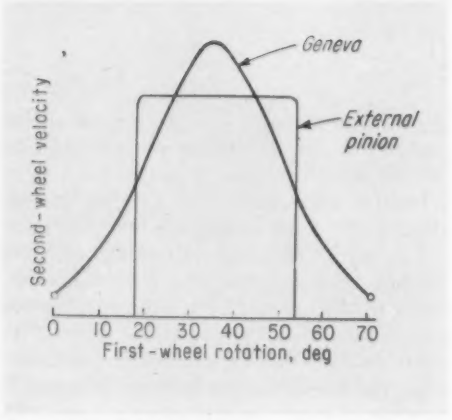
A Geneva transfer, plus small wheels, is an obvious combination that works if not carried too far. Yet more counters with 1-in. wheels have Geneva transfers than the smaller sizes, because the bigger wheels need the help most. Smaller-wheeled counters can run faster without a Geneva transfer precisely because they are smaller and lighter. As the counter gets smaller, the Geneva wheel gets more difficult to make, and the sliding pin becomes dangerously thin for its high rate of wear. As a result, a counter with wheels smaller than 0.700 in. dia rarely has a Geneva transfer.

A second way to make lightweight wheels is with light material—either an aluminum-and-steel combination or plastics.

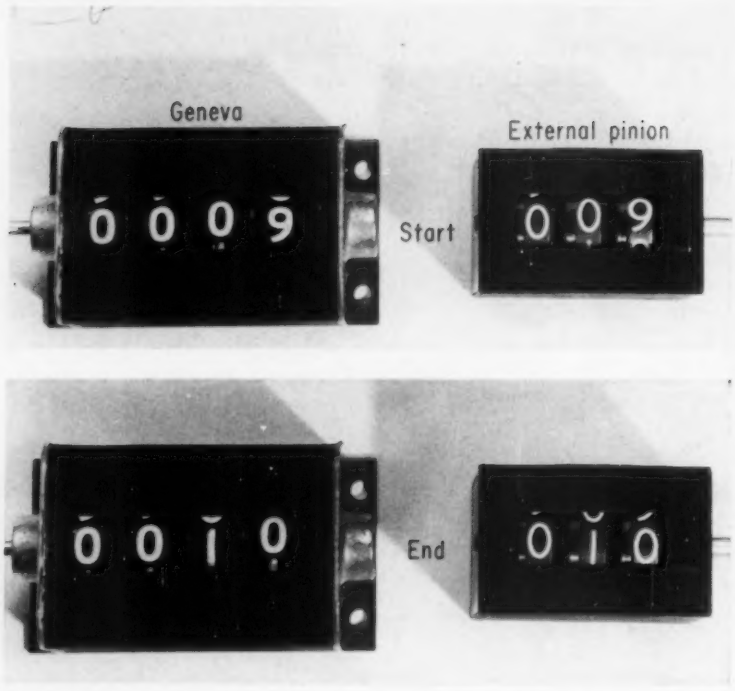
With metals. Those who prefer metal wheels do so mainly to pass government salt spray and humidity tests. There is no speed loss with metals, but they cost more. Instead of a one-piece molding, the wheel is a built-up combination of aluminum shell and steel transfer gear. Low-cost stamped gears don't last above 800 to 900 rpm without a Geneva transfer, or above 1200 rpm with it. Higher speed counters must use more expensive hobbed gears.

At low speeds, gears are of stainless steel, but hardened steels are required for the highest speeds, and the steel





GENEVA TRANSFER reduces high acceleration—chief cause of wear in an external-pinion transfer. Thus, velocity of second wheel builds up slowly instead of almost instantaneously, and period for transfer is twice as long.



AMBIGUITY is greater with Geneva transfer than with external-pinion transfer, but this direct comparison shows little actual difficulty in reading. Readings mark limits of significant movement of the second wheel, rather than where transfer theoretically starts and ends.

needs protection from corrosion. The plating to protect it—copper-nickel, chromium, zinc or cadium—adds an extra cost.

For shafts the softness that disqualifies stainless steel for high-speed gears is an advantage, because it makes pinning easier.

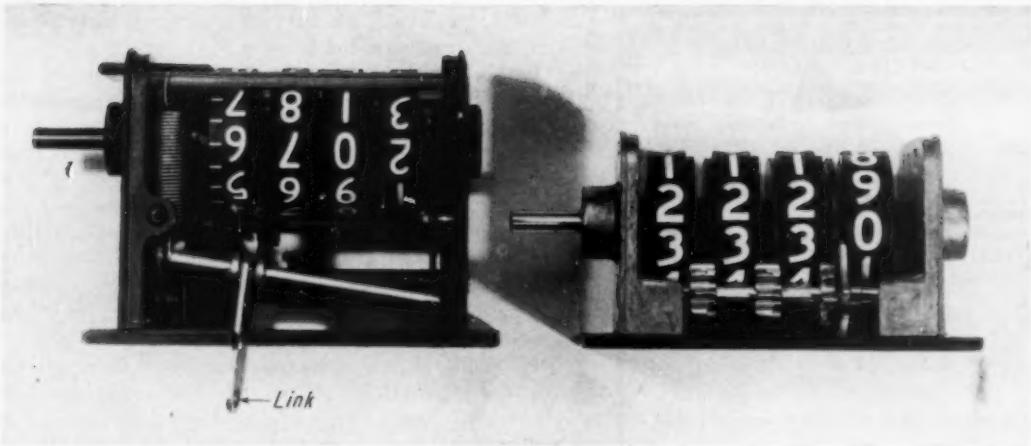
Pinions should match the transfer gears—stainless to stainless, hardened steel to hardened steel—except when they are of powdered metal.

With plastics. When deciding on a plastic, expect to compromise between its high-speed qualities and its tendency to grow (expand with heat and moisture). Lightness is the main advantage of plastics at high speeds, and is why counters with plastic wheels and pinions can go just as fast as their all-metal counterparts—even without a Geneva transfer.

One company which has made a comparison on the basis of moment of inertia, offers a plastic middle wheel with 1 in. dia and a moment of inertia of 1.47×10^{-4} in.^{4}, only 45% of the 3.25×10^{-4} in.^{4} of the metal wheel.

An extra advantage is the low cost of one-piece moldings. However, when parts are too complicated for molding, as in angle or latitude-longitude counters, plastics can't be used.

The most desirable properties for high speed are high impact strength and high wear resistance. The search for these two properties narrows the choice to nylon, Nylatron and Delrin. Nylon has been the most widely used because



CORRECTED READING COUNTER (left) is larger and more expensive than standard counter at right, because it needs additional mechanism to make reading clear. Ambiguous readings result from 10:1 gearing between first and second wheels, which allows speeds of 6000 rpm. When link is pulled, clarity of reading equals that in ordinary counter.

it has both good impact strength and good wear resistance. Accumulation of working experience with the relatively new Delrin has shown that it wears 10% less than nylon, so it now dominates the field.

Nylatron (nylon impregnated with the dry lubricant, molybdenum disulfide) wears only half as fast as nylon; it's used in pinions.

If it weren't for heat buildup, plastics could run much faster. At continuous high speeds the temperature rise in the wheels and pinions softens the material. When the counter runs at the same speed for short periods of time, the plastic has a chance to cool. Thus the counter will last longer, even at higher speeds, if it doesn't run continuously.

Dimensional stability

Plastics "grow" four times as much with temperature as does aluminum, and unlike metals, swell by absorbing moisture. By growing axially along the shaft, plastic wheels can bind. By growing radially, plastic transfer gears and pinions can jam.

There are partial remedies for growth—without need for finding a material that is more stable dimensionally. Proper molding technique can control grain direction so that most of the growth is axial. And certain fillers will reduce growth in all directions.

Changes in mechanical design will also help get around growth. A simple spring washer at the end of the wheel shaft, where the wheels turn slowest, allows the wheels to grow along the shaft without binding. Another brake on axial growth is to extend the sleeve bearings in the wheels slightly beyond the sides of the wheel. Then, instead of plastic-to-plastic contact there is metal-to-metal contact—and little expansion.

Radial expansion calls for compensators; these widen the distance between the wheel and pinion shafts as the plastic grows. Often these are plastic inserts which carry the pinion shaft in the frame. In a counter with heart-shape cams, where the pinion shaft swings back during reset, the return stop can be a plastic compensating bar.

Many materials can stand up at low speeds, hence there is a wide selection to match environment. But only a few materials can take the punishment of high-speed impact, so the most dimensionally stable material is not always your choice. For instance, polypropylene would almost eliminate growth problems, but hasn't made the grade in high-speed wear tests.

Nylon used to be the overwhelming favorite for high speeds. Then Delrin came along, and outclassed nylon in dimensional stability. At first, counter designers saved Delrin for high heat and humidity, but have since found that it also wears better than nylon. Result: Delrin has largely replaced nylon.

Low torque

Two sources cause most torque: acceleration of the wheels during transfer, and friction.

Acceleration of the wheels again puts a premium on lightness. More gradual acceleration also lowers torque—another advantage of the Geneva transfer.

Important points of friction, besides at the bearings, are at the wheel surface where the pinion locks, and between the pinion and the transfer gears. Reducing friction at the locking surfaces is a matter of picking materials that slide easily on each other, but getting the pinion and transfer gears to mesh smoothly is a matter of precision. It takes care and accuracy to make the wheels and pinions concentric, to make their shafts parallel, and put a fine finish on the teeth.

For counters, ball bearings are not the torque reducers one would imagine. At −60 C, where oil thickens, they do reduce torque, but at higher temperatures oil-impreg-

IMPORTANT PROPERTIES OF PLASTICS FOR HIGH-SPEED COUNTERS

	Nylon	Nylatron	Delrin	Aluminum
Izod impact strength, ft-lb/in.	2.0	0.62	1.4	——
Rockwell hardness	R 108	——	R 120	——
Tabor abrasion resistance (CS-17 wheel, 1000 gm), mg/1000 cycles	6-8	better* than nylon	20	——
Specific gravity	1.14	1.33	1.43	2.70
Water absorption (24-hr), %	1.5	1.5	0.4	——
Thermal expansion, in./in./F $\times 10^{-5}$	5.5	2.8	4.5	1.29

* In tests where plastic samples rub steel, Nylatron wears only half as much as nylon

nated sleeve bearings work as well and are cheaper. Occasionally, ball bearings are needed to limit axial and radial movement or to cut impossibly high torque on some heavy metal models down to a reasonable level.

Counters carry a full complement of bearings—at wheel shaft ends, wheels and pinions—except occasionally at nylon pinions. To meet an especially low torque specification, it will help to burnish the bearings by pushing a precision ball through them.

The lubrication of counters isn't quite as mysterious as some manufacturers indicate. The makers do use a wide variety of mineral and synthetic oils and dry lubricants. But most of these lubes are standard; only a few are really secret. Your main job here is to pick that lubricant out of the array which matches the expected temperature range.

FUTURE

The Geneva wheel and the external-pinion counter are old. It was several hundred years ago when the Geneva wheel first prevented overwind on a Swiss watch. And as far as mechanical counters are concerned, there are no new mechanisms on the horizon.

New materials, on the other hand, are already showing a route to counters having longer life at higher speeds. With introduction of nylon, counters with plastic parts began to compete with all-metal versions at speeds over 1000 rpm. And recent development of the more dimensionally stable Delrin has put plastics on almost even terms with metals. Some have worked out better than others. For example, such impact-resistant and dimensionally stable plastics as polycarbonate and polypropylene, which appeared simultaneously with Delrin, have shown disappointingly fast wear.

No matter where counter-makers stand today on the question of metals vs plastics, there is no disagreement about tomorrow. The search continues for plastic that will be light, impact resistant, wear-resistant and dimensionally stable.

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EDITOR'S NOTE: We thank these three experts for the information they contributed to this article: Bernard J Glista, Durant Manufacturing Co, Milwaukee; Edward J McConnell, Veeder-Root Inc, Hartford, Conn; Lowell D Temple, Bowmar Instrument Corp, Fort Wayne, Ind.

More information on digital display and mechanical counters will be found in these previous articles:

Digital Readouts, Oct 31 '60, p 46—Covers 14 basic types—mechanical, electrical and electronic; tells how they work and how to pick the right one.

Selecting Counters for Digital Display, May 16 '60, p 106—Author explains advantages of a mechanical counter over other digital displays and what he found out about them when he needed one that would go 1000 rpm with low torque.

The Right Mechanical Counter, Apr 17 '61, p 41—Tells what a user should know when he is going to design a mechanical counter for high or low speed into his product. Stresses how smart specifications can stretch counter life, and gives the basic causes of counter torque and inertia.

—Bruce H Frisch

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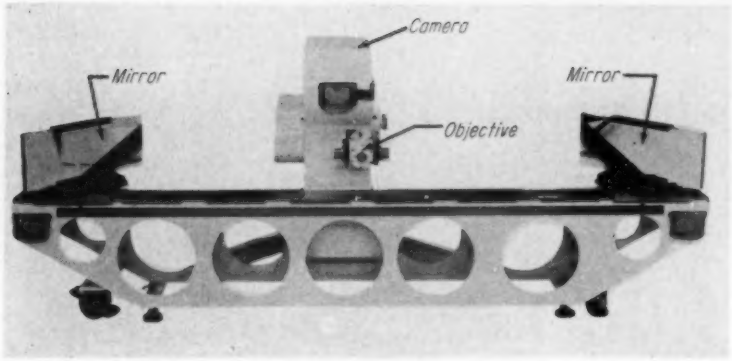
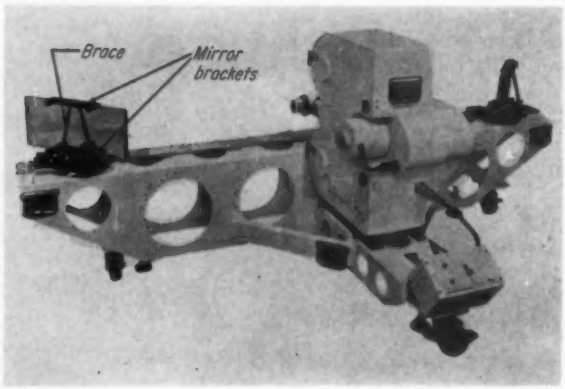
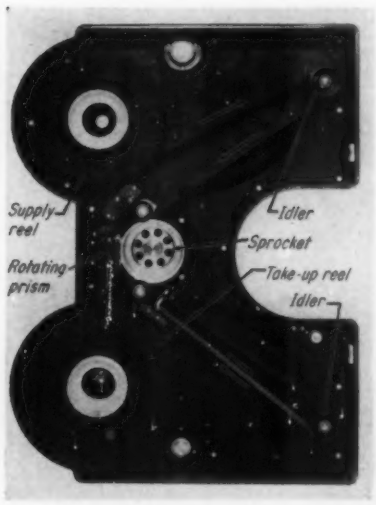
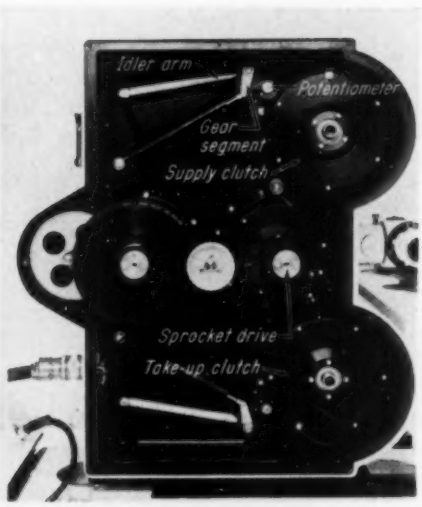


Breakaway camera records explosions

Mirrors in folded optical path can break away to prevent transfer of blast force to camera. Idler movement controls reel speed and film tension during acceleration.







EXPLOSION TESTS are performed in a banked arena with two ports through which the mirrors view the subject. This permits the camera to be shielded from the direct force of the blast. The mirrors reflect the image to be recorded to the 180° opposed objective lenses. Since the camera structure must be accurately leveled and adjusted, it is undesirable for the force of the test explosion to be transmitted to the camera structure. Shock waves passing through the viewing ports will break the mirrors without harming the camera mounted between them. Unframed glass mirrors are retained in two brackets joined by an adjustable brace for tilt correction.

FILM TENSION CONTROL is provided by idlers. Film-tension idlers are mounted on arms whose movements are damped by shock snubbers. Gear segments mounted on the idler arms rotate the input shafts of two potentiometers. The potentiometers regulate current to clutches in the supply and take-up reel drives.

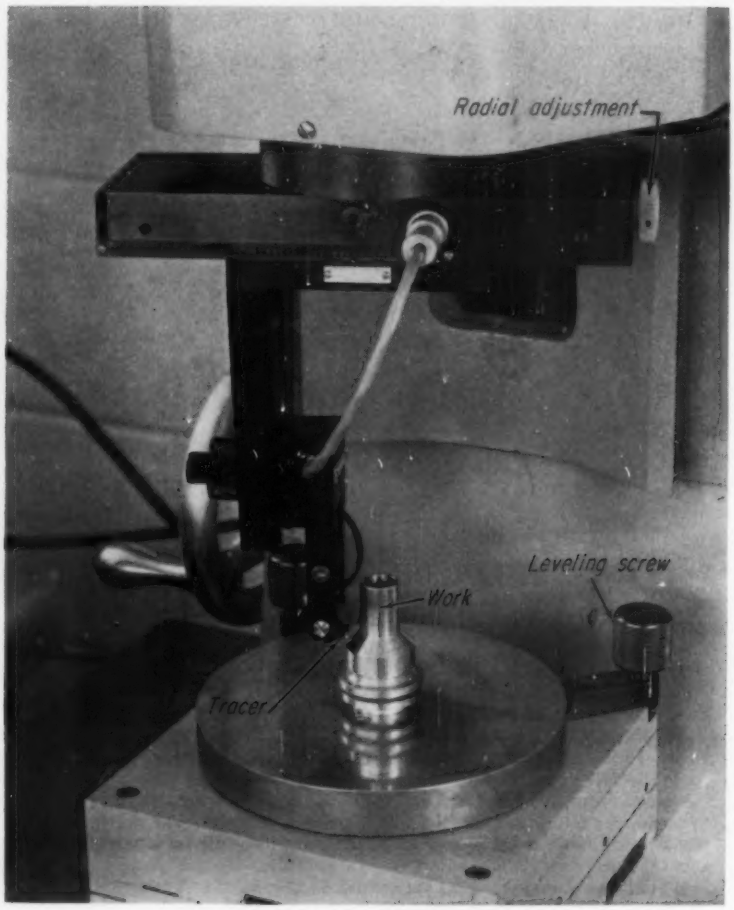
Supply reel starts out at maximum clutch-coupling force and maximum film tension and feeds film slower than the sprocket takes it up. As the film tension pulls the idler and its arm toward the sprocket the potentiometer connected to the arm reduces the clutch-coupling force. This permits the supply reel to overrun, reducing film tension until the idler and its arm reach an equilibrium position. The take-up reel idler and its potentiometer control the clutch in the takeup drive in the same way. The idlers also adjust reel speed as the reel diameter changes. This prevents film breakage and stripped sprocket holes.

PS...Continuous motion, rotating prism camera uses 35 mm (2 strips of 16 mm pictures) film to record explosions at up to 15,000 frames per sec in 3D. Seven frame rates are possible: 700, 1000, 2000, 3000, 5000, 10,000, and 15,000. Stereoflex Model A camera is produced by Benson-Lehner Corp, Santa Monica, Calif.

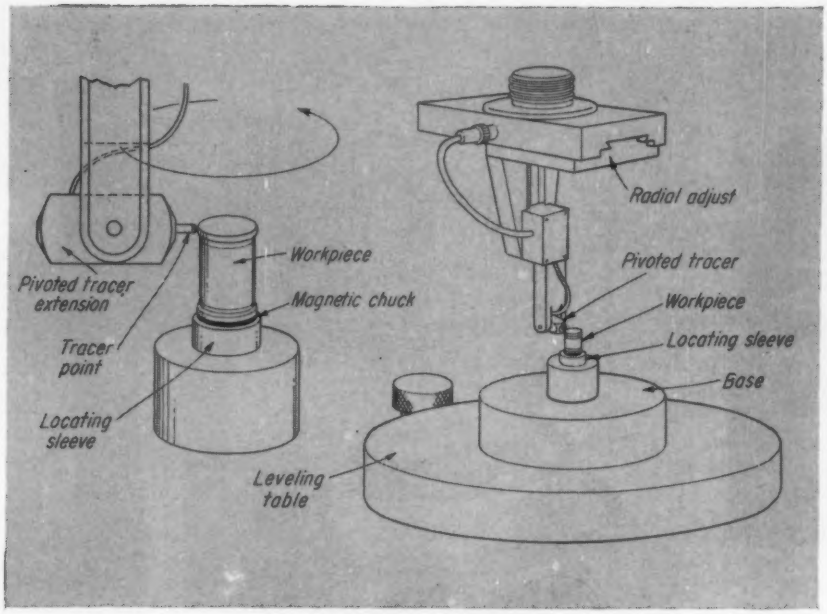
—William B Wallace, Los Angeles

Feeler records surface roughness

Displacement of diamond stylus is magnified and signal recorded on strip chart for permanent record. Output of linear variable-differential transformer is multiplied 50,000 x for visible indication of surface irregularities less than 0.000,005 in.

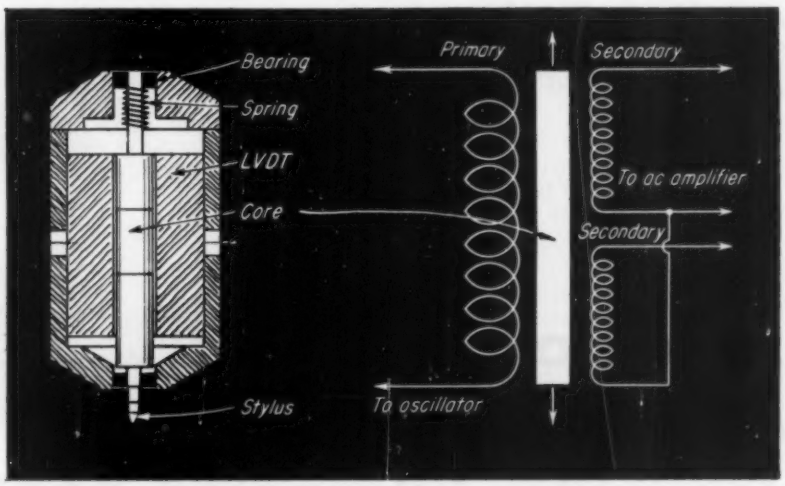


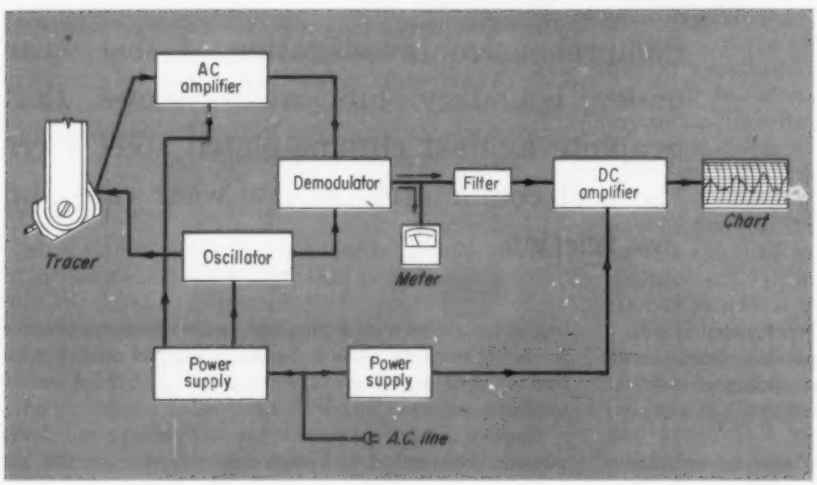
ROTARY PROFILE RECORDER is mounted on the console-desk which contains the electronic system, recorder and instrument panel. The setup meter on the panel is used in aligning the tracer to the workpiece. Other controls on the panel are the power switch, trace control, vertical-radial sensitivity and profile selector. The radial sensitivity control provides five different selections: 5μ, 25μ, 100μ, 250μ and 1000μ per ¼-in. division on the chart. The profile selector gives the operator a choice of three profiles: 1) Total, 2) Waviness, 3) Roughness. The recorder is also adjustable for circumferential sensitivity, tracing and chart speed. The rotary manipulator provides a circular tracing motion required for measurement around surfaces of rotation plus a work table for the workpiece. The tracer is attached to an adapter which can accommodate work from 1/32 to 8 in. OD and ⅛ to 8 in. ID. Work table has a cross slide plus a leveling table that permits adjustment of the workpiece.



SURFACE CHECK of cylindrical workpiece is made by mounting the piece on the leveling table and rotating the tracer around it. Workpiece is positioned on the table and the axes of the work and tracer path aligned. Radial adjustment of the tracer, plus the cross slide and leveling table permits the operator to align the axes precisely. After selecting the type of profile and the desired radial and circumferential sensitivity, chart and tracer speed are adjusted for the size of work being inspected. In operation the manipulator rotates the tracer around the work, recording the movement of the stylus in contact with the surface to be checked. Production setup for surface check uses a magnetic chuck and locating sleeve to reduce alignment time.

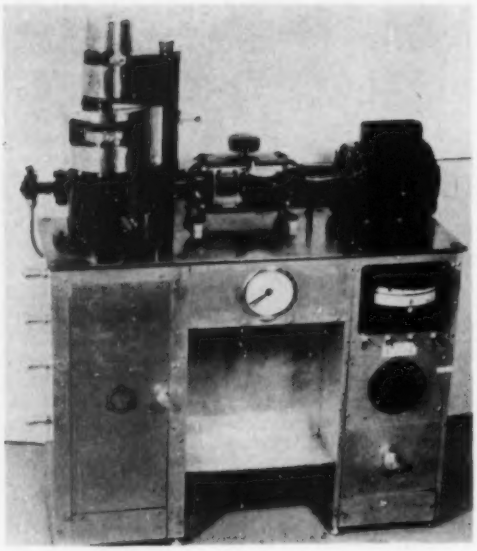
TRACER STYLUS is mounted on core of a linear variable-differential transformer. The spring-loaded core acts as a magnetic coupling between the primary and secondary windings. The change in coupling produced by core movement as the stylus travels over the surface produces an electric signal. The two secondary windings are combined to double the signal output. Input to the transformer primary is from an oscillator. The transformer secondary or output passes through an ac amplifier, demodulator, filter and dc amplifier. The dc amplifier output is used in the chart pen drive to produce the record of surface irregularities.





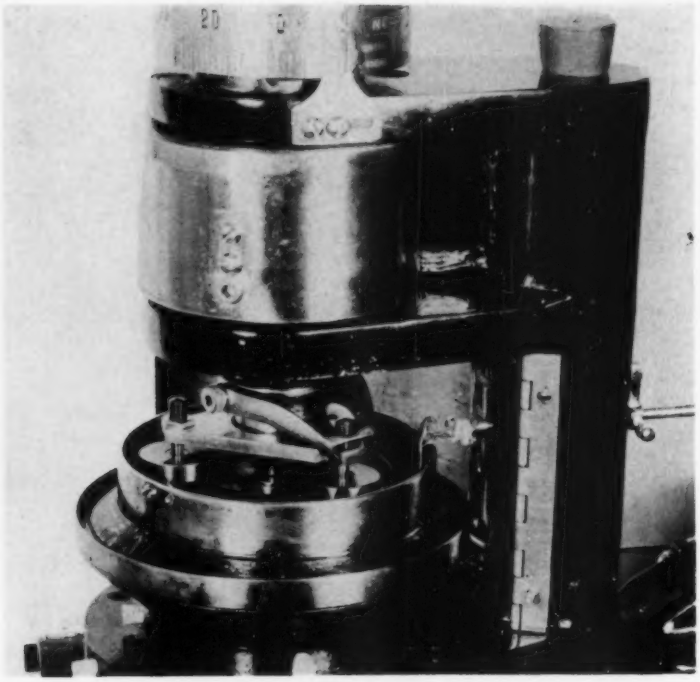
PS...System consists of an electronic console with chart recorder, tracers and mechanical manipulators which move and support the tracer. At the highest vertical magnification, 50,000 x, a ¼-in. division on the chart equals 0.000,005 in. At the highest horizontal magnification on the chart, 500 x, a ½-in. division equals 0.001 in. Styli are also available to profile ID's as small as 0.040 in. Nominal stylus pressure is 0.8 gram and is adjustable. Manipulators for linear, rotary and internal linear motions are available. Proficorder system is produced by Micrometrical Co, Ann Arbor, Mich.

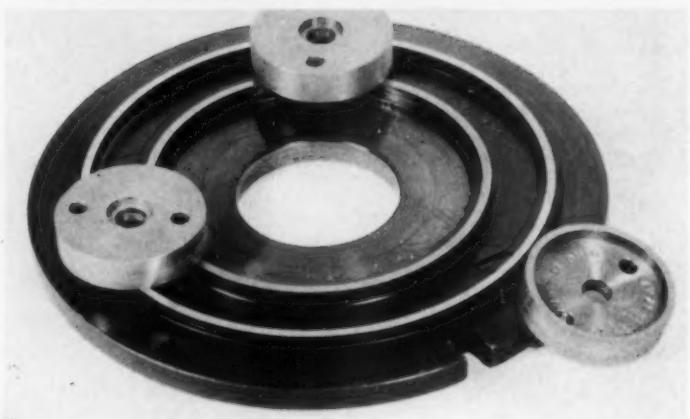
—Felix Giordano, Detroit.



1

KINETIC OILINESS TESTING MACHINE rotates rails of shaft material under wear plates of seal material at selected normal loads and speeds. Water lubricant is added to cover the rails, and temperature is held constant by a controller. Wear rate is measured by weight loss of wear plates; friction torque is shown on drum on top of machine.





FRICTION AND WEAR for water-lubricated seals

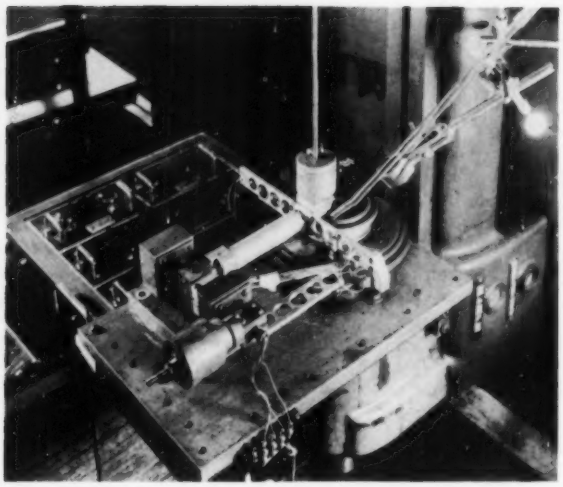
Comprehensive investigation of seal wear under boundary lubrication shows that graphite against chrome-plated steel gives the best combination of low wear rate and low friction.

LT ROBERT L CORNELL, *United States Navy*
LT ROBERT S LUCAS, *United States Coast Guard*
LT HAROLD L YOUNG, *United States Navy*

■ Controlling seal wear and friction under water lubrication is a difficult problem. While boundary lubrication appears to be the controlling factor, the coefficient of friction, corrosion resistance and physical properties of mating materials also are important.

To find the best combination of seal material and mating surface, wear tests were made on carbon and laminated phenolic running against bronze, K-monel and against Stellite-faced and chrome-plated steel. Lubricant was a synthetic sea water.

Carbon compositions with higher hardness and lower porosity were found to have the lowest wear rate for the



2

FOR SENSITIVE MEASUREMENT OF WEAR this machine uses a specimen 0.036 dia held against a wear surface on a horizontal disk rotated at constant speed of 355 rpm. Specimen has a 10 deg conical point, held against the wear ring by gravity load; friction torque is measured by a strain gage on a restraining spring. Water lubricant is dropped on wear ring just ahead of point of contact.

Conclusions presented here are drawn from a comprehensive investigation conducted at the Department of Naval Architecture and Marine Engineering at Massachusetts Institute of Technology. While the objective of the study was to obtain design data for seals on submarine propeller shafts, the test methods developed are useful for rating seal materials for water lubricated bearings where relative speeds are in the boundary lubrication range.

This comprehensive investigation included some 31 seal materials and five different shaft materials under a wide range of load, speed and temperature conditions. Tests presented here have been selected as representative of service conditions of broad interest, and are typical of materials exhibiting good performance.

The authors report that "good and consistent results were obtained with Graphitar, grade 14, made by United States Graphite (carbon #1 in the test data). Graphitar Grades 47 and 48, and P-16-A made by Pure Carbon Co ranked close."

seal material. Phenolic materials were a "distant" second for both wear rate and friction; they gave best performance when used against a Stellite facing. Hardness of the shaft material had almost no effect; best wear performance was given by chrome-plated steel against carbon.

Wear under these conditions is the result of many little-known processes. It occurs primarily at points of actual contact, or asperities—not as a uniform smear. High unit loads at these tiny asperities results in adhesion or welding, with discrete fragments broken off by relative motion. Temperatures of 2000 F or higher appear likely at asperities—in the range where carbon is reactive. This can involve reduction of metallic oxides, oxidation of the carbon, and formation of metallic carbides. The inherently high reaction temperature of chromium and its resistance to carbide formation suggests that this is a major factor in good performance of chromium plating in reducing wear.

Detectable wear does not occur until a given unit load is exceeded; up to this point local hydrodynamic lift forces fully support the load. Above another higher load condition increase in load produces no increase in rate of wear.

Friction values were smallest with carbon on bronze, but wear was lowest with carbon on a chrome-plated surface.

What didn't work

Carbon against aluminum bronze produced galling, variable friction and extremely high wear rate. Hardness and density of carbon had little effect.

Carbon against K-monel produced higher wear rates than against Stellite, chrome-plated steel or bronze.

While harder carbon in general gave longer wear there was no correlation between hardness and wear rate; some softer carbons performed better than some hard compositions, but highest wear rate was on the softest carbon.

Wetting agents in the lubricant increased the friction somewhat.

Repeated tests of wear rate often varied as much as 20%, but order of merit did not change.

How the tests were made

Preliminary tests to determine the relative performance of seal material combinations under water lubrication were made on a kinetic machine designed to operate under boundary lubrication where the effect of lubricant viscosity is minimized. Unit loads, speeds and contact areas were selected to duplicate service conditions in marine propeller shafts.

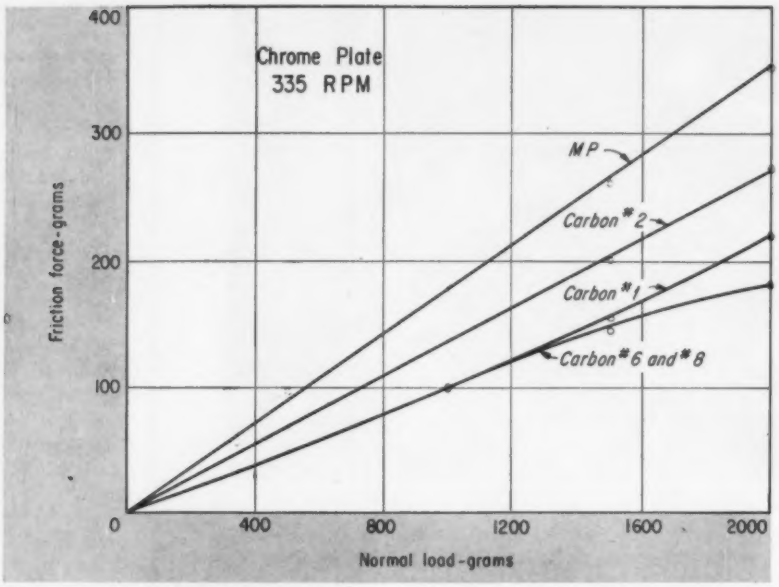
Sliding surfaces consisted of three wear buttons riding on two concentric sharp-edge rails. Wear buttons were machined from various grades of carbon and laminated phenolic; rail materials were bronze, Stellite and chrome-plated carbon steel. Contact surfaces were held flat to 5 microinch, and run in to get constant friction before starting a load test.

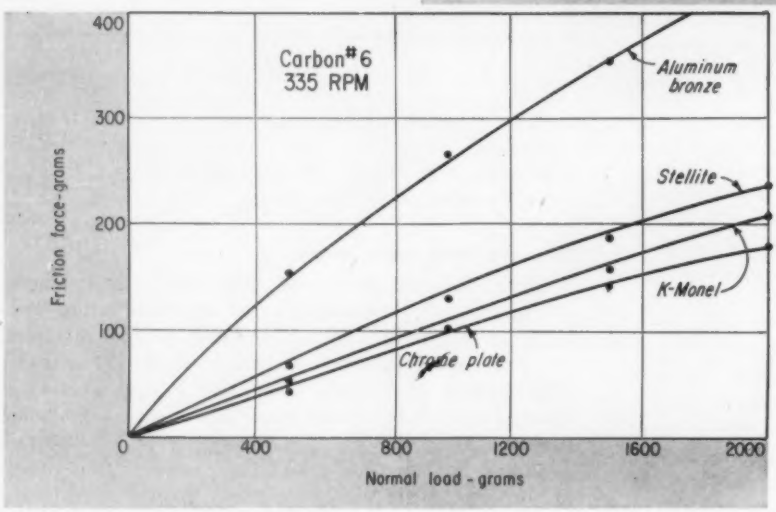
Track surfaces were covered with a lubricant in the form of a synthetic sea water. The wear buttons were rotated at a desired speed, a selected gravity load applied for a predetermined time and the friction torque measured. Temperature was held constant at a level above room temperature by a controller. At the conclusion of a test run, the buttons were removed, cleaned and weighed to measure wear loss; the track was removed, cleaned and wear surfaces measured with optical flats. Maximum speed of the track was 550 fpm, loads were up to 2000 psi, tests ran 1 to 15 min, at temperatures from 50 F to 475 F.

Wear buttons were prepared from eight laminated phenolic materials, four common grades of carbon. Wear surfaces on the tracks were 10% tin bronze, Stellite #6 welded to SAE 4140 steel, and 0.015 in. chrome plate on SAE 55100 steel. Procedure for each test included short runs at successively slower speeds and shorter time, at se-

FRICTION AND SEAL WEAR

continued





3

CARBON ON CHROME PLATE gave lowest friction, as shown by data on effect of seal material (above) and shaft material (left) on seal friction at varying loads under synthetic seawater lubrication.

lected loads with temperature held constant. Friction was measured at each speed and load.

These preliminary tests indicated that non-impregnated carbon materials with low graphite content would give lower friction coefficient, but wear rate was influenced strongly by hardness. Lowest coefficient of friction was obtained from carbon on bronze, but the wear rate was at least twice as high as for carbon on chrome plate.

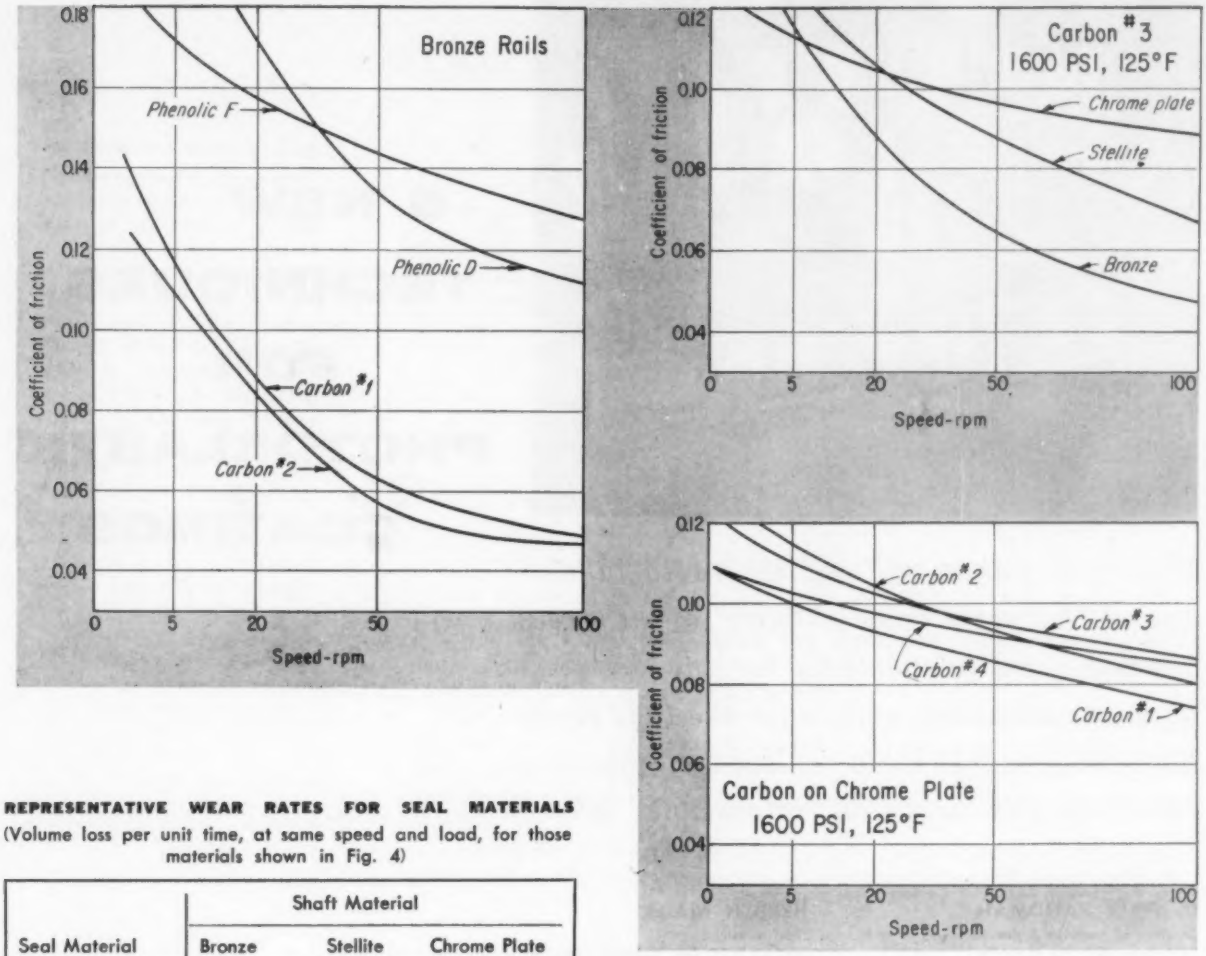
Based on these tests, a more detailed study was made on another test stand which held a vertical specimen with a conical tip against the horizontal face of a rotating disk. Water lubricant was dripped just ahead of the contact. Normal load was provided by dead weight, and friction force was measured by strain gage on an elastic restraining member. Wear was measured optically by a microscope. Specimens were 0.036 in. dia with a 10 deg conical point; the disk was rotated at a constant speed of 355 rpm, corresponding to a linear speed of 5.4 fps.

For wear tests, the specimens were mounted and run dry with 1000-gm load until friction force was constant. Then, the load was changed to 2000 gm and lubricant added; test run was 30 min, occasionally 15 min. At end of the run the tip diameter was measured, and wear in cu mm calculated.

For friction tests, loads were in steps of 500 gm with friction force measured at each step.

Friction results by this method proved repeatable within 10%, but wear results were more sensitive to minor differences in materials even of the same batch.

Effect of increasing load on friction force is shown in Fig 3 for a series of carbon materials on chrome-plated steel; and for a low-friction carbon material on five different rail materials. Effect of speed on coefficient of friction at a heavy load is shown in Fig 4 for four carbon materials on chrome-plated steel, for one carbon composition on three different rail surfaces, and for carbon and phenolic materials on bronze rails. Carbon #1 on chrome plate had the best combination of low friction and wear.



4

BOUNDARY LUBRICATION increases coefficient of friction at low speeds, but coefficient varies substantially with seal material (left), with shaft material (top), and with grade of carbon (below).

REPRESENTATIVE WEAR RATES FOR SEAL MATERIALS
(Volume loss per unit time, at same speed and load, for those materials shown in Fig. 4)

Seal Material	Shaft Material		
	Bronze	Stellite	Chrome Plate
Phenolic F.....	43	34	26
Phenolic D.....	14.3	10.0	13.7
Carbon #1.....	0.6	0.28	0.13
2.....	2.7	1.6	0.16
3.....	1.6	2.2	0.20
4.....	0.6	1.1	0.23

Materials used in these selected tests were:

Specimen	Type	Source
Carbon #1.....	Graphitar 14	United States Graphite Co
2.....	Graphitar 30A	"
3.....	Graphitar 35	"
4.....	Graphitar 39	"
6.....	Graphitar 86	"
8.....	P-61-A	Pure Carbon Co
MP.....	Oilless plastic	Arguto Oilless Bearing Co
Phenolic D.....	Ryertex SBE-50	J T Ryerson & Sons, Inc.
Phenolic F.....	Insurok XT-883	The Richardson Co

EDITOR'S NOTE: These earlier articles have discussed friction and wear problems with water as a lubricant.

Rotating Seals for High Pressures, Feb '56, p 140—Selection of seal face materials with emphasis on problems faced with higher pressures.

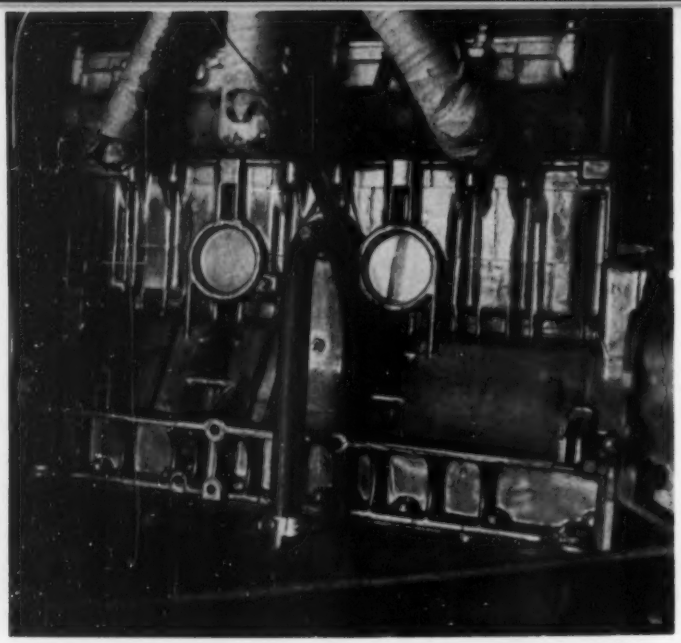
Water-lubricated Fluid-film Bearings Are Practical, Sep 30 '57, p 74—Recommendations for bearing and face materials; design data on friction loss under boundary lubrication.

How to Design Ball Bearings for Water Lubrication, Oct 28 '57, p 72—Recommendations for race and ball materials.

Immersed Motors, Sep 15 '58, p 80—Discusses bearing problems for open construction immersed motors, concluding that rubber bearings are best for salt water and graphite for fresh water.

How to Choose a Dynamic Seal, Mar 20 '61, p 57—Tabulates properties of materials for face seals.

—Robert W. Carson

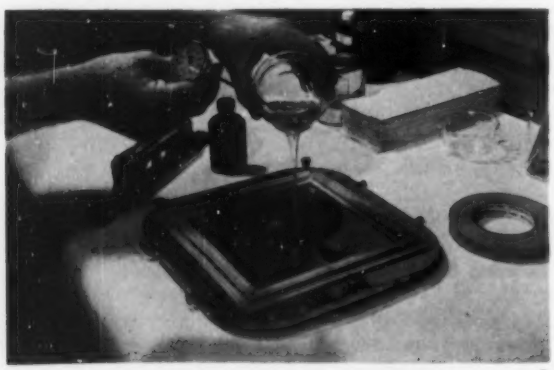


6 NEW TECHNIQUES FOR PHOTOELASTIC COATINGS

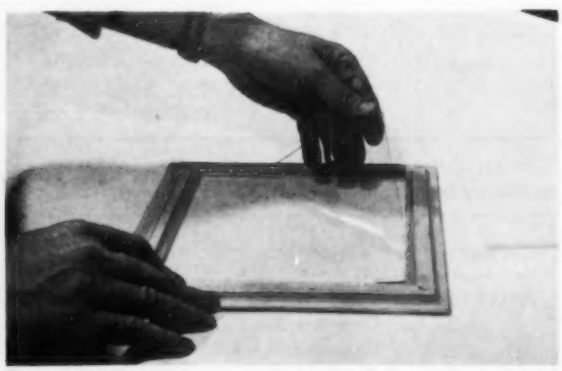
Where to put metal and where to take it away? That is the basic problem for the stress analyst—and particularly for the designer of a new aluminum engine for the 1961 Rambler (see cover). Here are six techniques to eliminate guesswork on "impossible" jobs.

Dr FELIX ZANDMAN
Director of research & development
Instrument Div, The Budd Co
Phoenixville, Penna

HERB N MAIER
Chief physicist
Doehler-Jarvis Div, National Lead Co
Toledo, Ohio



A



B

1 . . . Deep contouring starts with a mixed 2-component resin which is poured on a flat, level, silicone-varnished glass plate to the desired thickness (A). Mixing and all the later steps in the contouring process are done at room temperature.

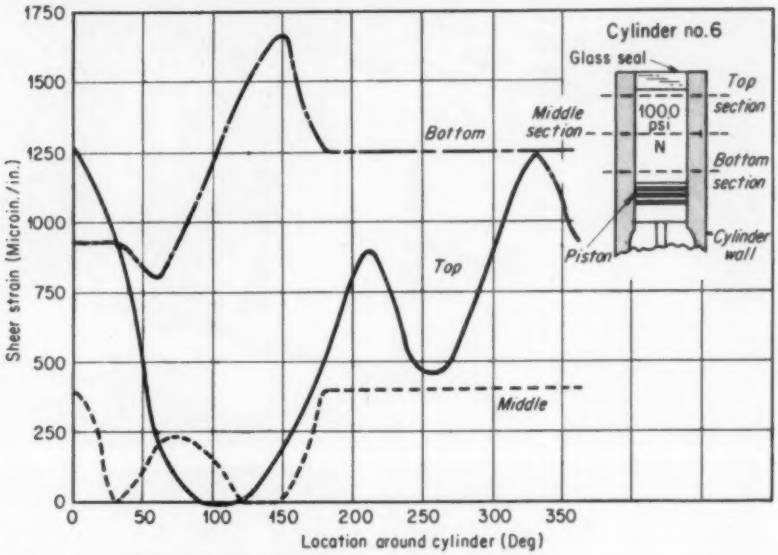
After 2-hour cure the plastic has polymerized to a cheesy consistency. It is lifted off the plate (B) and may be cut (C), or punched for ease in contouring to the desired shape (D). The process is simplified with a light coat of mineral oil on the part to ease contouring and reduce sticking.

An additional three to four hours stiffens the plastic so that it may be lifted from the part. Part and plastic should be cleaned with acetone prior to bonding. Now a reflective cement is applied and the contoured plastic replaced; 24 hours later the part is ready for test. Cement may be applied during the first contouring, but the 2-step procedure makes a neater job.

PHOTOSTRESS A QUICK REVIEW

This technique of stress analysis consists of bonding a layer of photoelastic plastic to the part to be analyzed. When load is applied to the part, surface strains are transmitted to the plastic coating. Viewed through a reflection polariscope, the strains show up as black and colored patterns. Black fringes give the directions of principal stresses within 2°; colored fringes give the magnitude of principal strains as well as their sign. Compensators used in the polariscope permit quantitative readings within 10 microinch/in.

The coating is elastic and reversible, so static and dynamic strains are measured with equal ease. See PE — Sep '56, p 167 for a full description of the method, and Oct 24 '60, p 42, Mar 2 '59, p 43 for two devices based on the principle.



2 . . . At 1000 psi inside the cylinder strains vary considerably around the periphery and at different heights. Strain patterns were found also to be quite different from cylinder to cylinder.

Contoured sheets were applied to the walls, the cylinder head sealed with glass, and nitrogen at 1000 psi introduced. Note the piston is at bottom dead center—unrealistic for these pressures, but a critical test of cylinder strength. Measurements were made through the window with correction for obliquity of light.

To check the effect of pressure on the plastic a strip of metal was coated and pressurized to 1000 psi. As expected, no parasitic effects could be measured. ■

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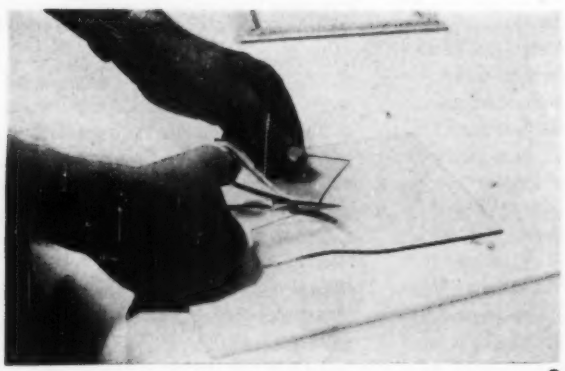


C

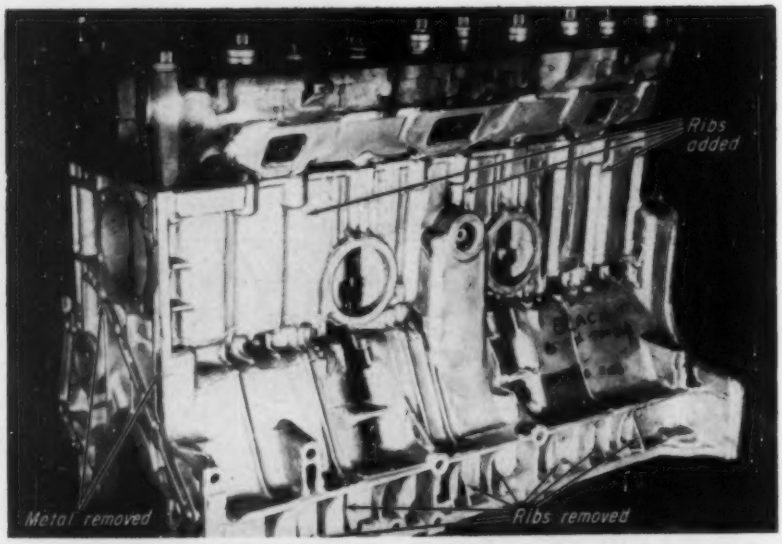
D

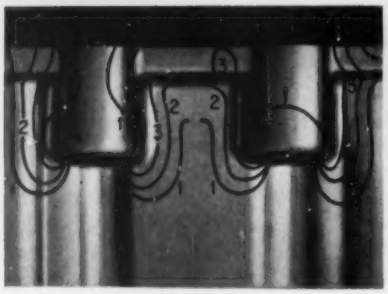
Photos from Doehler-Jarvis Research Bulletin No. 3.

If the part is large or complicated, separate pieces of plastic may be placed side by side, much as a tailor cuts a suit. The gaps are filled with clear PhotoStress cement and the result is a continuous coat. When loaded, the fringes will be continuous as well—extending right through the joinings.

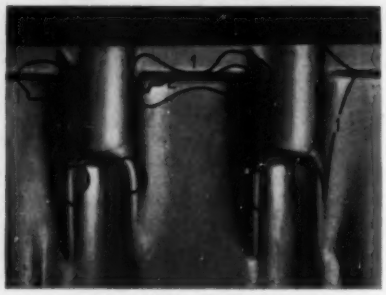
Originally, it was suspected that coating thickness might vary considerably when the sheet was contoured into sharp fillets on the engine. Later measurements proved this to be untrue. Thickness of the plastic used on the engine was 0.070 in. and variations did not exceed 0.003 in. Of course this required the tailoring technique mentioned above. Radii of ⅛ in. have been contoured with this plastic without difficulty.

Time to apply a coating varies considerably, depending on complexity of the part. In this case a complete engine (95% of the exposed surfaces) was coated by two experienced technicians in three days. ■





A. Original Design



B. After Redesign

3 . . . Redesign "in metal" reduced maximum stresses and made stress gradients much less severe. Bolt bosses (A) were coated with plastic and the engine assembled by torquing the bolts to set values (first 15, then 30, then 45 ft-lb). Every increment in torque or difference in sequence of bolts tightened, changed the stress distribution completely not only in magnitude but in direction of principal stresses.

Note the pattern in (A) as originally designed. Fringes have been numbered indicating the following strains:

Fringe No.	Shear strain (microinch/in.)
0	0
1	1800
2	3600
3	5400

A fourth fringe was present as well, but is hidden in this view. Instrumentation is available to measure 1/100 of a fringe, therefore providing a strain sensitivity of 18 microinch/in. for the plastic used in this test.

By modifying the bosses maximum strain was reduced to second-order fringes, and then only in isolated spots (B). Yielding is avoided and the assembly is safe, no matter what sequence of bolt tightening is used.

The engine block was then placed on a milling machine and ribs removed one at a time with an end mill to observe what would happen to the stresses associated with these ribs and at their junctions with the vertical walls. It was possible to eliminate objectionable stress concentrations in most cases by the judicious use of fillets and other internal coring changes not noticeable on the outside. In the end a total of approximately 4 lb of aluminum was removed from the original design.

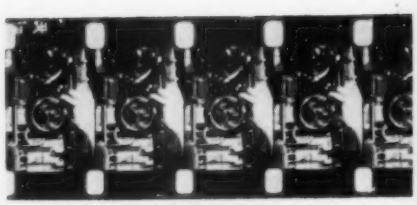
Wherever there were areas of low or zero stress, metal was removed—when permitted by fabrication considerations. Some highly stressed areas were shaved away as well, in effect "chasing" the stresses to other parts of the block. Stress redistribution meant reduction of stress concentrations and a slightly higher stress level over-all.

This approach of removing metal while observing stress redistribution is a most effective and elegant method of redesign. ■

4 . . . Thermal stresses result from unequal expansion coefficients. The Rambler engine block is aluminum, its head and cylinder liners are cast iron.

There are several ways to check thermal stresses. Cold water was poured into the water passages to produce temperature gradients similar to those in a running engine. As a double check, hot water was also poured into the cylinders to produce similar gradients.

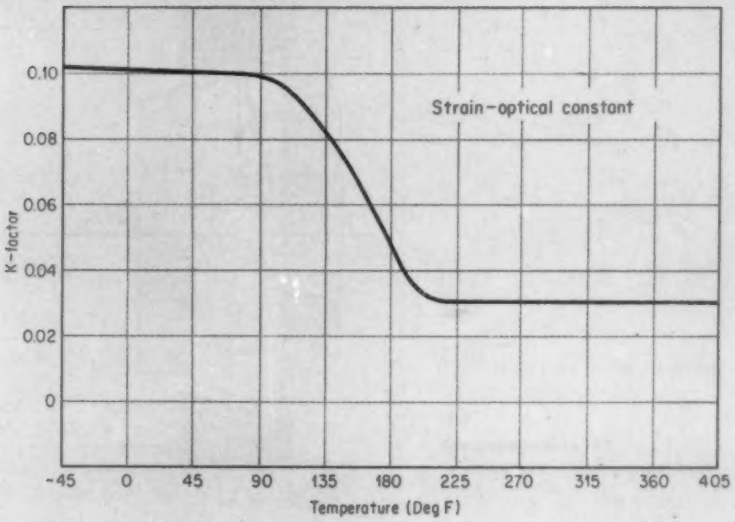
But how does the plastic react? The curve here shows change in strain sensitivity as a function of temperature. Note that from 200 F to over 400 F and from −40 F to 100 F the strain-optical coeffi-

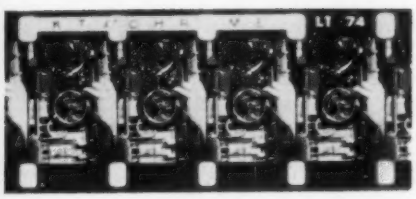


5 . . . Dynamic stresses were observed under synchronized strobe light and also recorded with a high-speed motion picture camera. Strobe frequency, slightly out of phase with the frequency of cylinder firing, shows the dynamic effects in slow motion. It is fascinating to watch the changing stress pattern for each firing of a particular cylinder—but the basic pattern established by bolt torques and modified by temperature strains is essentially unchanged. The variation of strains caused by cylinder firing is only a few percent—this is as it should be or no engine could resist the fatigue of millions of cycles of stress change.

cient is constant. In these areas stress calculations are easy. In the transitional range, between 100 F and 200 F, a different coefficient must be used for each temperature.

Around edges of the plastic, parasitic birefringence will occur if temperature of the test is different from temperature at which the plastic was bonded to the part. This is because the coefficients of thermal expansion of metal and plastic are different. The parasitic optical effect at edge of the plastic will correspond to an apparent strain of 20 microinch/in/°F for a PhotoStress plastic 0.070 in. thick. This value must be subtracted from the total reading at the edges. ■





The directions of principal stresses do change as each cylinder fires.

It is important to note the value of color motion-picture and still photography in analyses of this kind. The film record replaced written reports for the design team. Quick decisions, based on the knowledge of the entire group, were possible since all could share the experience of the test engineer without his needing to write long reports of observations, and the others having to study them. Further, no written report or drawing can be as graphic as a view of the actual test on film. And each review teaches the experimenter something new. ■

6 . . . Measurements in inaccessible areas

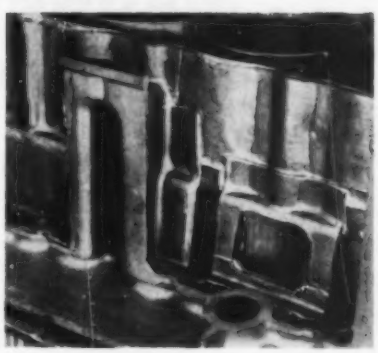
are a challenge to ingenuity—there are always danger spots where you can't throw light or see reflections. Here are some techniques that may be useful:

• Portholes may be bored in enclosing walls and, if necessary, replaced with a window to permit viewing normally inaccessible internal areas. Here, the water jacket wall (right) was cut away to show the walls carrying hold-down bolt threads. Loads were so evenly distributed that thread inserts were unnecessary—an enormous saving in manufacturing cost.

Viewing can also be done through transparent liquids like water, gasoline, light oil or gas since these do not affect optical characteristics of the system. This method measured stresses on inside walls of the engine block.

• Mirrors, of course, can channel light to the part and back to the measuring instrument. Also, fiber optics are a natural for this purpose—some with both light source and return in the bundle. Borescopes of conventional design would also work.

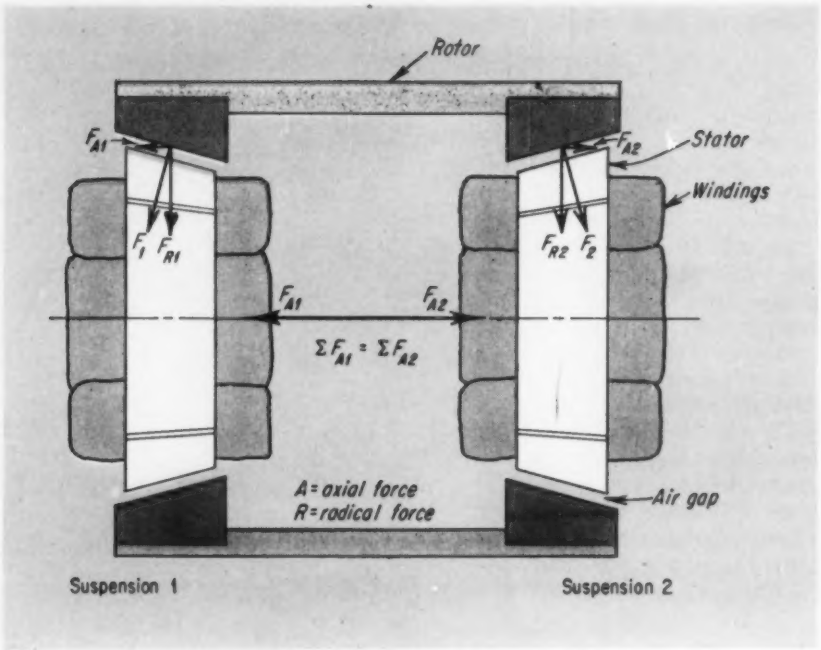
• Cameras, still or motion-picture, may be placed where a man's head and instrument can't. Closed-circuit TV, black-and-white or color, will serve the



same function. Camera techniques have been used in the missile industry, especially for analysis of the inside walls of pressure vessels.

• Part may be loaded beyond the yield point, then disassembled and inspected. Areas of yielding will carry a permanent photoelastic pattern. This technique produces a distorted part, however, which may be undesirable.

• Part may be loaded before plastic is applied. After full polymerization of the cement, the load may be removed and the part disassembled. The coating will carry the pattern of strains with reversed signs. In this so-called "relaxation" method, only strains within the elastic limit will be shown. ■



1 . . . Three-dimensional electromagnetic suspension.

just around the corner?

. . . MAGNETICALLY SUSPENDED BEARINGS

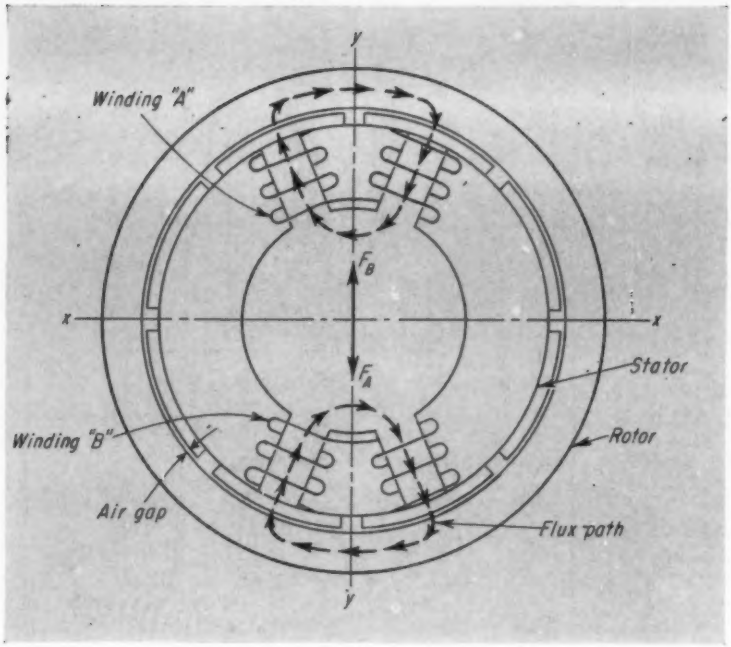
Already in gyros—where they completely eliminate friction by avoiding metal-to-metal contact—they show possibilities of competing with air bearings for lightly loaded instruments. But their load capacity must be upped before they leave the gyro field.

NICHOLAS P CHIRONIS
Associate editor

■ A unique system of electromagnetic suspension, developed at the Instrumentation Laboratory, MIT, by P J Gilinson Jr and G A Garcia, may soon pave the way to the use of magnetic bearings for lightly loaded instrument applications. Key advantage of magnetically suspended bearings is complete elimination of friction. Low load capacity (less than 1 lb in the gyro application) is the main limitation. But one need only recall how air bearings were faced with a similar hurdle, a few years ago, to safely predict substantial improvements in the near future.

At present, the new system has made it possible for the Nortronics Div of Northrop Corp, at Norwood, Mass, to build integrating gyros with an accuracy 10 times better than what was previously possible. Development work at Nortronics has been headed by H Packard.

The construction of this system is relatively simple. The rotor, Fig 1, is a tapered ring of ferrite. (In the gyro application, the inner member is stationary and the outer member rotates—however, the system can be easily constructed with the outer member stationary and containing the coils.) The stator ring, also of ferrite, is machined to match the taper of the rotor. The stator is very much like a spin motor stator except that it is excited by a single-phase ac. Both the stator stack and the rotor have low magnetic reluctance, so that the inductance of each pair of stator windings is determined by the geometry of the



2 . . . Flux path and basic elements of suspension system.

stator-rotor gap. This gap is 0.0005 to 0.001 in. Only radial or axial motion of the rotor affects the inductance of each pair of windings.

Here, the most significant feature of what could be called a levitation system is its tuned capacitor circuit which, contrary to expected magnetic behavior, increases the flux or attracting force at any point around the rotor-stator gap as the gap at that point increases. Four pairs of coils, each with a capacitor in series, are connected in parallel to a single-phase, ac excitation source.

By tuning the circuit so that it is operating at the upper half-power point of the resonance curve, or, put another way, so that the magnetic forces have negative gradient, the rotor is returned to its geometric center whenever a radial force tends to displace it.

The electrical circuit

The stator, Fig 2, is a laminated stack of electrical grade laminations, with the stack height located in the z-axis (not shown). The outer periphery of the stack is slotted with four sets of windings located in the slots. Two sets of windings in the y-axis are shown diagramatically; a similar pair lies in the x-axis (not shown). Superficially, this wound stator resembles an inside-out spin motor stator, the main difference being in the winding layout.

Concentrically surrounding the stator is a magnetically soft rotor with an airgap between the stator and rotor. In appearance the rotor resembles the hysteresis ring of a spin motor.

Condition of unstable equilibrium

The windings are connected to an ac source with a resultant flux pattern as shown in Fig 2. Assume that: (1) the rotor and stator are located in perfect concentricity with respect to each other, resulting in equal airgaps for each flux path; and (2) the ampere-turns are equal for both windings in the axis, so that the magnetic flux caused by winding A is equal to that of winding B.

Under these conditions, there is a magnetic pull on the rotor from each winding. The pulls are equal; therefore no resultant pull exists and the rotor is fixed in position with respect to the stator. The basic pull, either F_A of F_B, is given by the equation:

$$F = KB^2 = K_1\left(\frac{I}{g}\right)^2$$

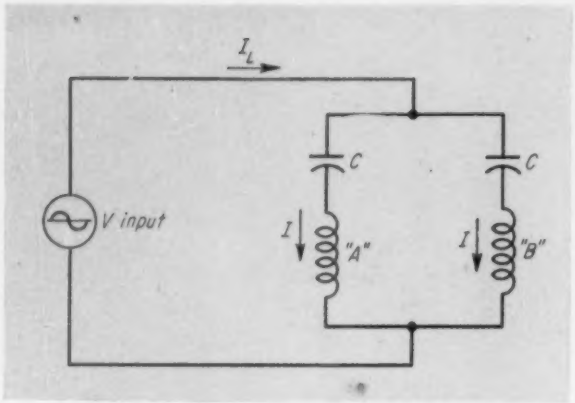
where K and K_1 = constants
B = flux density in the airgap
I = current in either winding
g = airgap (radial) between stator and rotor.

But, as described, the suspension is in a condition of unstable equilibrium. Any displacement of the rotor toward the stator results in an increasing pull at an increasing rate (refer to above equation). The effect snowballs, occurring virtually instantaneously so that the rotor comes into physical contact with the stator and will remain in forceful contact unless the power to the windings is interrupted.

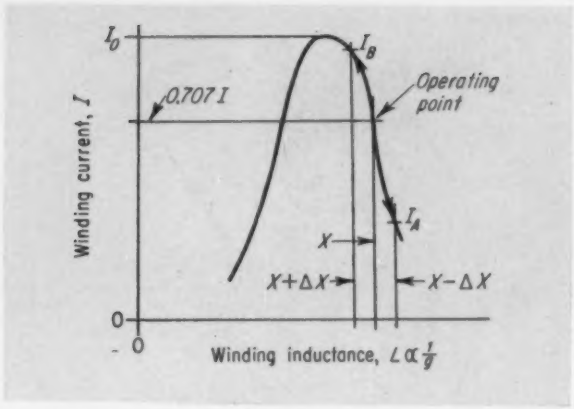
Condition of stable equilibrium

To operate the suspension in a condition of stable equilibrium, capacitors are located in an electrical circuit, Fig 3, with values C so selected that the operating value of winding current lies on the upper half-power point of the resonant curve (Fig 4). Thus, under balanced conditions, the airgaps facing the windings A and B are equal and given by X in the curve.

When an external force now causes the rotor to be displaced downward, the airgrap at A decreases and the gap at B increases. If we call the change in airgap ΔX, the gap at A becomes $X - \Delta X$ and the gap at B becomes $X + \Delta X$. Because the winding currents must lie on the



3 . . . Electrical circuit for y-axis suspension only.



4 . . . Resonant curve of suspension.

resonant curve, the current of winding B increases to I_B and that of winding A decreases to I_A. For winding A, the pull is now

$$F_A = K_1\left(\frac{I_A}{X - \Delta X}\right)^2$$

where $I_A < 0.707\ I_o$, and where I_o is the resonant current per coil.

For winding B

$$F_B = K\left(\frac{I_B}{X + \Delta X}\right)^2$$

where $I_B > 0.707\ I_o$.

Note from these equations that the change in winding current is opposed by the change in airgap with respect to the basic pulls.

If the Q of the windings were extremely low, for example, less than 2, the percentage change in airgap would be greater than the percentage change in winding current resulting in a condition of unstable equilibrium.

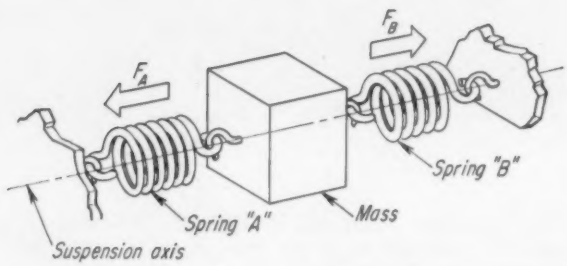
In practice, however, Q normally will lie between 5 and 10 so that I is much greater than ΔX. Under these conditions there is a net pull along the axis equal to $F_B - F_A = \Delta F$ in a direction to restore the rotor to its original X position. A similar analysis holds if the rotor is displaced in the opposite direction.

Under proper operating conditions, therefore, the electromagnetic suspension operates in a condition of stable equilibrium. Changes in rotor position are automatically counteracted by changes in the winding currents which alter the airgap pulls. The resultant pull on the rotor restores it to its original balanced-force condition.

Mechanical analogy

In performance, electromagnetic suspension is analogous to suspension of a mass between two identical springs, Fig 5. In the balanced position, the springs are under equal tension. However, if an external force deflects the mass to the right along the suspension axis, the pull caused by spring A increases, and the pull caused by spring B decreases, tending to return the mass to its original position. If the deflecting force is removed, the mass returns to its original position (assuming no hysteresis). Electromagnetic suspension inherently has no positional hysteresis along its suspension axis.

If the springs are made extremely stiff (high spring rate), large external forces are required to move the mass.



5 . . . Mechanical analogy for electromagnetic suspension.

This ability to resist movement is termed "suspension stiffness" and is given in force per unit deflection. A typical suspension stiffness for electromagnetic suspension is 5 to 50 grams per 100 microinches; in other words, an external deflecting force along the suspension axis of 5 to 50 grams will move the rotor 100 microinches. This stiffness can be changed by changing the excitation current.

Three-dimensional suspension

The discussion thus far has been concerned with suspension only along a single axis. It is also valid for suspension along the X-axis by simply requiring stator windings in this axis. To obtain suspension in three dimensions, a pair of suspension units are required with conical airgaps, as shown in Fig 1.

With low flux-density levels in the stator and rotor iron, the basic pull (F_1 and F_2) upon the rotor by the stator occurs normal to the airgrap surface. This basic pull is readily resolved into radial (F_{R1} and F_{R2}) and axial (F_{A1} and axial (F_{A1} and F_{A2}) components. The axial components, of course, produce the axial suspension forces. Under balanced conditions, F_{A1} is equal to F_{A2}. This analysis for radial suspension also holds for axial suspension.

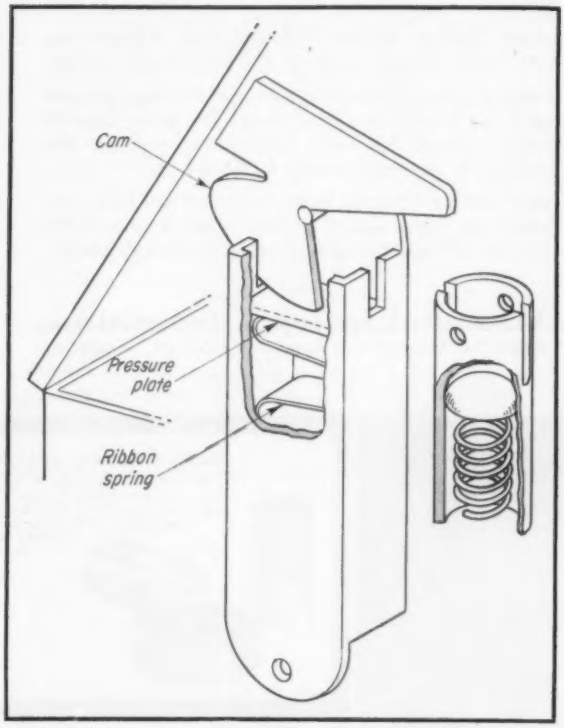
EDITOR'S NOTE: This article is the latest in our continuing coverage of developments in the bearings field. For a combined reprint of articles presenting the design considerations in the selection and application of ball and roller bearings, order a copy of the new 64-page reprint "Rolling Element Bearings" from Reader Service Dept, Product Engineering, 330 W 42nd St, NY 36. Price $2.

—Nicholas Chironis

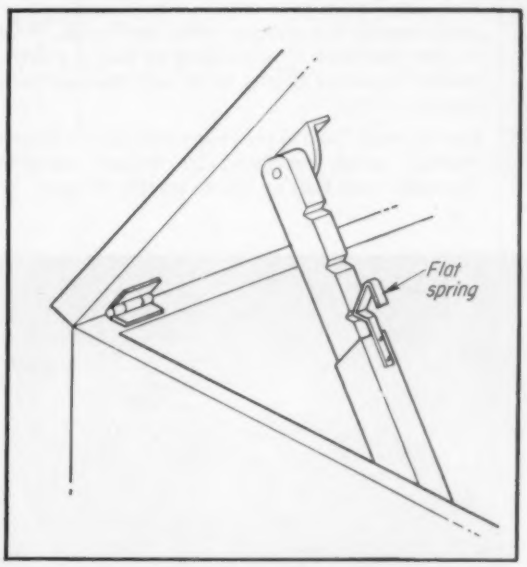
PANEL-STOPS LEAVE HANDS FREE

They hold open panel doors while repairs or adjustments are made (for 8 other examples, see the May 1 issue, p 63).

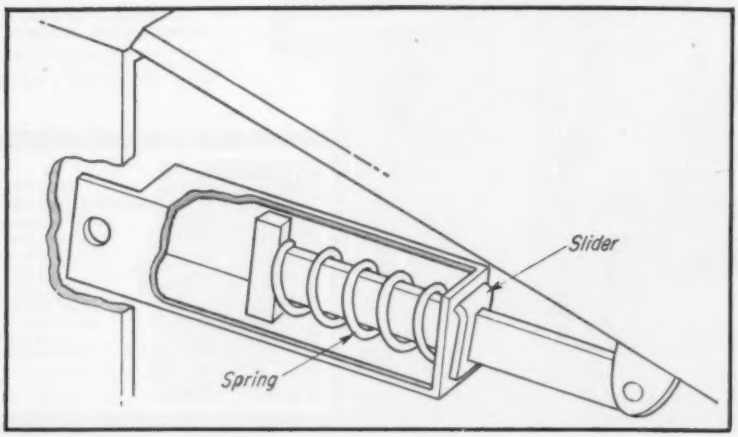
FRANK WILLIAM WOOD JR
President, Advanced Designs Inc
Vienna, Va



1
CAM rubs on spring-loaded pressure plate. Resulting friction holds panel open at any position. Tubular spring-holder has helical instead of ribbon spring.



2
NOTCHED BAR catches on flat spring at only a few positions. Serrations increase number of positions. Heavier flat spring holds by friction at any position.



3
SLIDER jams when pulled against spring case, but slides freely after raising the panel slightly releases pressure. Spring holds panel shut.

continued, page 51

Quiet...

WAGNER Polyphase Resilient Mounted Motors in ratings through 10 horsepower

Quiet, vibration-free performance is essential when motors are installed in areas where noise must be held to a minimum . . . in hospitals, churches, schools, office buildings, restaurants and similar locations where quiet is needed or wanted.

Such installations have created a need for larger polyphase motors that whisper while they work. Wagner has met this need by expanding its line of polyphase resilient mounted motors to include standard ratings through 10 hp.

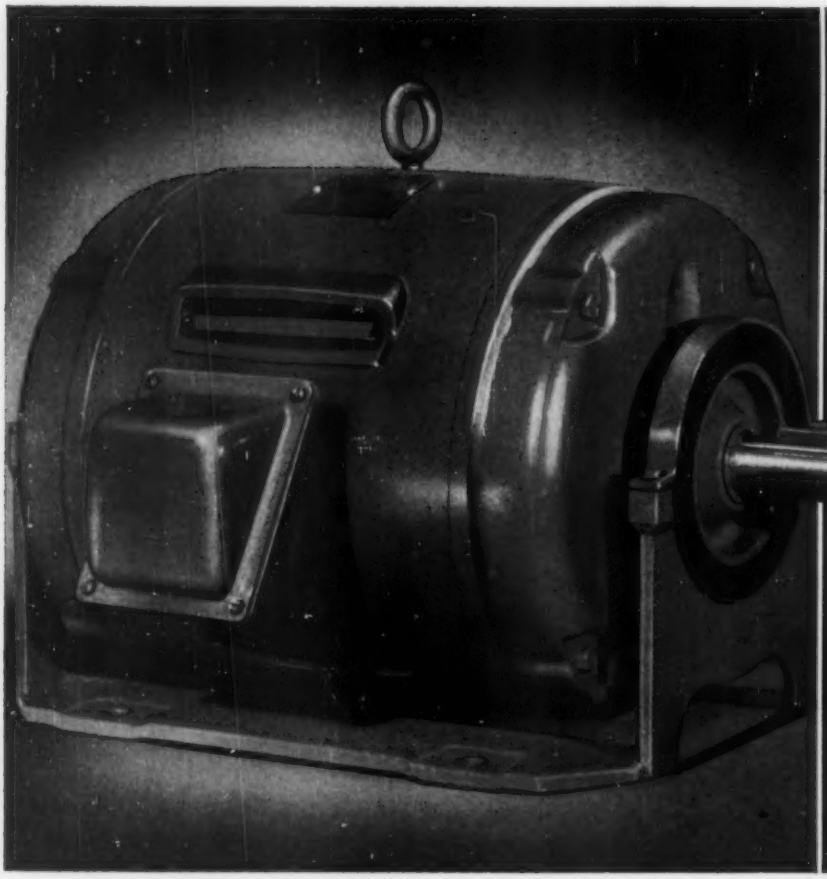
You certainly have applications that call for a smooth running motor, cushioned by resilient mountings. To make sure they're quiet, specify Wagner Polyphase Resilient Mounted Motors. Only Wagner can provide an entire range of ratings through 10 hp.

Constant research and development have kept Wagner up front in electric motor design for more than 65 years . . . made the name Wagner one you can depend on in choosing electric motor drives.

Your nearby Wagner Sales Engineer can help you select the right motor to meet your requirements. There are Wagner branch offices in 32 principal cities.

Wagner Electric Corporation
6406 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

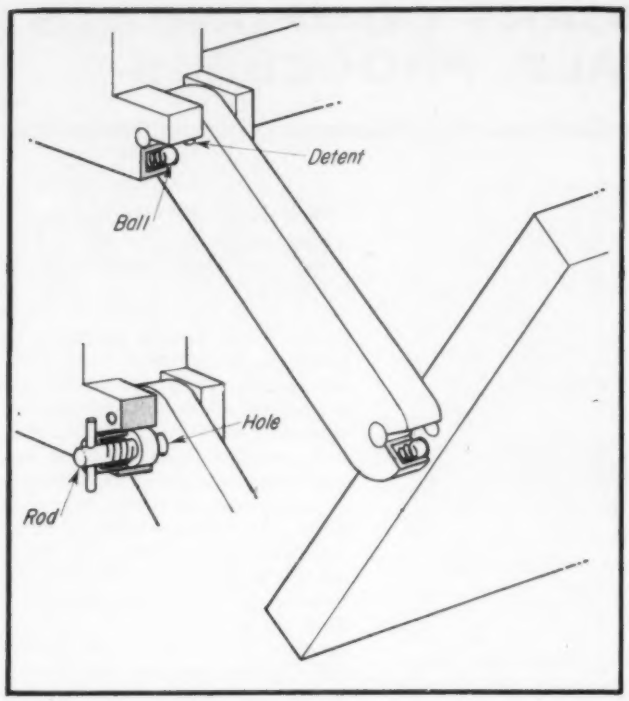
WM60-14



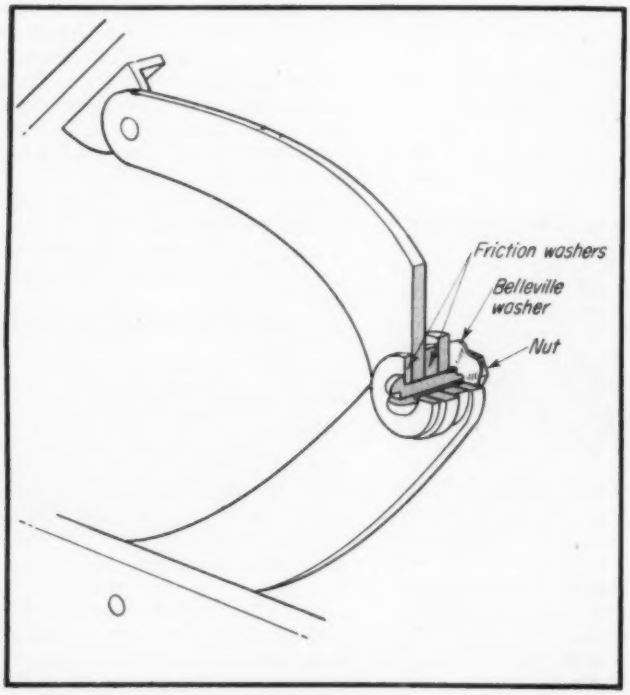
SLEEVE OR BALL BEARING
These motors are furnished with quiet running steel-backed babbitt-lined sleeve bearings of high load carrying capacity. Ball bearings can be supplied when desired.

CEILING, SIDEWALL OR HORIZONTAL MOUNTING
You can mount these motors on walls or ceilings by rotating the cradle base 90° or 180°. Motor stays dripproof.

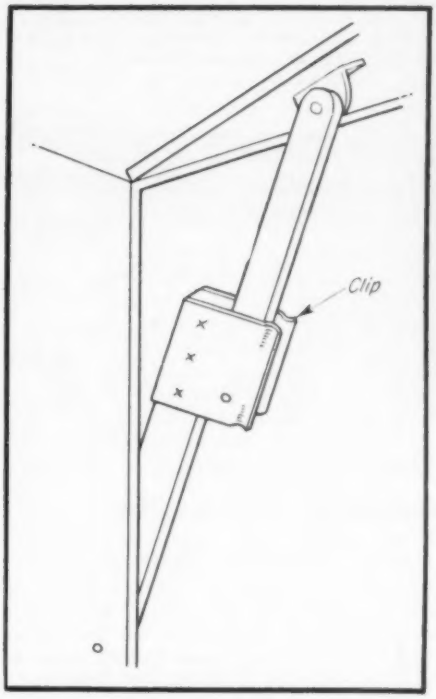
NEOPRENE CUSHIONING RING
Annular mountings, of oil-resistant neoprene bonded to steel rings, cushion the motor in its cradle base to absorb the small amount of vibration that remains in the most carefully balanced motor.



4
DETENTS at both ends of swinging bar cup spring-loaded balls. Rod snaps into holes for more positive hold, but must be pulled out to release. Both methods will hold panel shut.

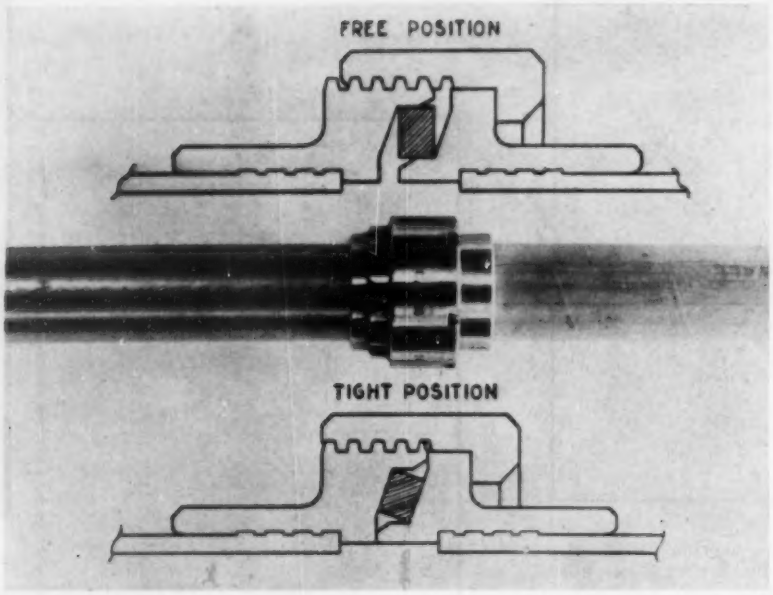


5
FRICTION WASHERS hold panel in any position, but are susceptible to vibration. Tightening down on spring washer adjusts drag for weight of panel. Knurled knob in place of nut allows tightening at desired position.



6
CLIP can hold panel door in only one position—open. Push on clip to release.

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Metal-sealed shaft coupling

flexes into sealing position when compressive forces are exerted on assembly. Said to maintain tight joint in extremes of temperature, shock, pressure and vibration. Seal is reusable, reversible and does not require special finish. Supplied in aluminum, alloy steel, stainless steel and in "rare" stainless steel configurations to accommodate all types of fluids at any desired pressure level from —425 to 1800 F. Available for ¼ through 3-in.-dia tubing. Other types in either tube or pipe sizes are also available. Price of stainless steel couplings with metal edge seals range from $20 to $40 each, depending on size and quantity. Delivery in 3 to 4 wk. **Gamah Corp, 1654 Lincoln Blvd, Santa Monica, Calif.**

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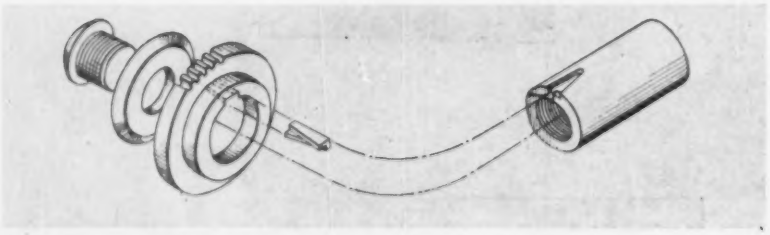

Double-taper lock key . . .

has lateral bearing surfaces of opposite longitudinal slope, allowing for a wedging action between key and shaft and key and gear. This reportedly eliminates any possible backlash or relative movement between shaft and gear. Same bearing surfaces align gear axially upon shaft, thereby eliminating need for a shoulder or similar retaining means. Key is available in widths of 0.156 to 1 in.; thicknesses of 0.156 to 0.750 in.; and lengths of 0.470 to 2.450 in. Keys 0.156 to 0.312 in. wide are packaged in boxes of 50 at $12.25 to $26.65 per box. Keys 0.500 to 1 in. wide are packaged in boxes of 25 at $17.50 to $35.85 per box. Delivery in 2 wk. **Sure-Lok Co, 7701 Melita Ave, North Hollywood, Calif.**

Circle 301 on Reader Service Card

Strain-gage pressure transducers . . .

include one model which has an overpressure stop and a second model which uses a special corrosion-resistant material. Former model permits two times rated pressure to be applied for 3 min. without causing a zero set to exceed 0.5% of full range output. Also allows ten times rated pressure, or 10,000 psi (whichever is less), to be applied for 3 min. without causing zero set to exceed 1% of full range output. Pressure ranges of this model are from 0-100 to 0-5000 psi absolute and gage. Rated electrical excitation is 10 v dc or ac rms at a carrier frequency of 0-20 kc. Sensitivity is 40 mv at rated excitation and 77 F. Combined effects of linearity and hysteresis do not exceed ±0.5% of full range output as measured from best straight line through calibration points. Second model's case and diaphragm are made of type 17-4 stainless steel. Pressure ranges from 0-100 to 0-10,000 psi absolute and gage, and combined effects of linearity and hysteresis do not exceed ±0.35% of full range output. Both models use unbonded strain-gage principle with a four-active-arm, spring-type sensing element and a diaphragm force summing area. Pressure against diaphragm produces a displacement which changes resistance of active arms. This, in turn, causes an electrical output precisely proportional to applied pressure. Stress isolation design prevents erroneous outputs caused by distortion or vibration. **Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena, Calif.**

Circle 302 on Reader Service Card

Air-dry solid-film lubricant . . .

is a one-coat process combining corrosion resistance and lubrication and eliminating need for other corrosion-resistant coatings such as paint, electroplate, etc. Parts coated with the lubricant reportedly have withstood 100-hr salt-spray tests with no visible traces of corrosion. Can be applied by spraying, dipping or spray-tumble and is only 0.0002 to 0.0005 in. thick with a coefficient of friction as low as 0.025 under high loads. Available in 50-gal. drums or 5-gal. cans. In production tests, 339 lb of die-cast aluminum parts at 45 pieces per lb used only 1 gal. of the concentrate. **Electrofilm Inc, 7116 Laurel Canyon Blvd, North Hollywood, Calif.**

Circle 303 on Reader Service Card

Self-tapping insert . . .

for installation in plastics, aluminum, magnesium alloys and other relatively soft materials, has wave-form threads extending its entire length except for end chamfers. These threads roll their way through base material without cutting. Base material is pushed back gently and then returns behind wave crest to lock insert with a zero tolerance fit. Insert has chamfers at both ends for installation from either end. Made of case hardened carbon steel, cadmium plated, and in sizes 4-40 through ¼. From stock with purchase of 100 inserts at 100,000-piece price. **SpeedSerts Inc, 6500 Avalon Blvd, Los Angeles 3.**

Circle 304 on Reader Service Card

Poppet valves . . .

are 2- and 3-way units with fingertip, ball cam, palm button and toggle action. Provide full ¼-in. flow and have cartridge inserts that can be replaced without removing valves from line. Aluminum bar stock bodies measure 1¼ x 1¼ x 1¼ in. **Superior Controls, Div of Superior Screw & Mfg Co Inc, PO Box 436, Commercial Rd, Crystal Lake, Ill.**

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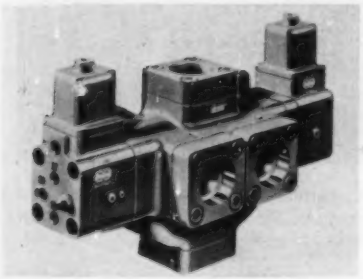

Pilot-operated solenoid valves . . .

are 2-, 3- and 4-way directional-control units for pressures up to 3000 psi (some 5000 psi). Available in ½-, ¾-, 1-, 1¼-, 1½-, 2-, 2½- and 3-in. pipe sizes. Solenoid is totally enclosed and sealed; has stem in cover to permit manual pilot valve operation for setup and trouble shooting. Pilot valve incorporates a built-in check and adjustable choke, allowing free flow in to shift directional plunger away from "operator" valve and restricted flow out when plunger is shifted toward "operator" valve. Alloy steel plungers are machined, hardened and ground for heavy-duty applications, while multiple tapered slots minimize shocks. **Oilgear Co, 1570V W Pierce St, Milwaukee 4.**

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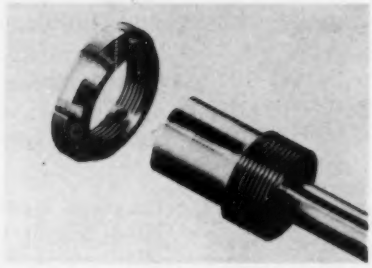
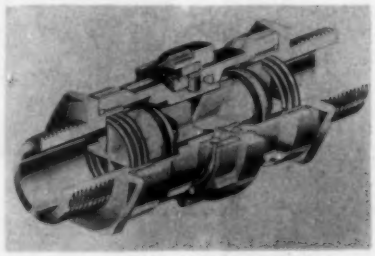


Bearing retainer nut . . .

suitable for any shaft application where a nut holds a bearing, eliminates use of tab washers and milled keyways. When nut is engaged with shaft threads, a nylon pellet imbedded in nut's threaded area exerts a strong cross-thrust against threads opposite the pellet. Result is a tight metal-to-metal engagement, creating a permanent locking and adjusting force. An infinite number of pre-load settings can be reached by using nut, and because it holds desired pre-load, nut eliminates excessive bearing wear. Available in any standard or special alloy and in all thread sizes. **Nylok Corp, 611 Industrial Ave, Paramus, NJ.**

Circle 307 on Reader Service Card



High-pressure quick-connect couplings . . .

are connected or disconnected with one quick twist (no springs are used to lock or unlock). Available from ¼ through 3 in. with internal pipe thread, male pipe thread and commercial hose end fittings and in alloy steel, brass, bronze and stainless steel. Ratings of 1-in. alloy steel coupling with standard seals include: proof pressure of 5000 psi; burst pressure, 7500 psi; temp range, 40 to 250 F; and pressure drop, 7.2 psi at 30 gpm. "Star"-shape valves (supplied in both nipple and socket, in nipple only, or socket only) provide max freedom of flow which reduces pressure drop across line when connected. In disconnect position, positive sealing action is assured by heavy stainless steel springs and O-rings recessed in valves. Locking pin provides max contact between lock pin, nipple groove and socket body, resulting in optimum load distribution and elimination of "brinelling." From stock. **Jack & Heintz, Div of Siegler Corp, 17601 Broadway, Cleveland 1.**

Circle 308 on Reader Service Card

Synchronous motor . . .

is suitable for "on-off" servo applications where 72-rpm speed and 1000 oz-in. torque are required. Can be started, stopped or reversed instantly with a single-pole, three-position switch. Output shaft can be stopped at 200 precise steps per revolution by using a dc power supply with appropriate switching. Ratings include: input, 120 v, 50/60 c, 1 phase; max current, 2 amp at 60 c; output speed, 72 rpm at 60 c; and torque, 1000 oz-in. Weighs 22 lb and is built to conform with Class 1, Group D explosionproof specifications. Can be used for remotely controlling gate and butterfly valves, machine tool carriage feeds, numerical positioning control systems, etc. **Superior Electric Co, Dept X100, Bristol, Conn.**

Circle 309 on Reader Service Card

Reversible counter . . .

is transistor-equipped unit with two inputs. Each input operates at high speeds over a frequency range of dc to 200 kc with an amplitude of from 1 to 10 v peak to peak in sine wave or square wave form. Unit adds and/or subtracts groups of pulses or square waves. A six-decade readout is furnished using in-line projection type indicators. Output from each decade can be presented in any common form. Pushbutton resets all decades to zero simultaneously, and individual pushbuttons on each decade preset numbers into counter. Rotary preset switches can be supplied to set an initial count. Priced from $1500 with delivery in 4 to 6 wk. **Wang Laboratories Inc, Natick, Mass.**

Circle 310 on Reader Service Card

Low-cost adhesive . . .

based on reclaim rubber, is suitable for flexible bonds between fabrics, cork, leather, insulation and wood, metal or glass. Can replace mechanical fasteners in securing weatherstripping, floor mats and insulation. Said to be water resistant and usable in ambient temperatures from —20 to 150 F. One gal. serves approx 250 sq ft of surface. Application can be made by brush or spraying with fluid pressure of 25

continued on page 56

JACOBSEN MANUFACTURING COMPANY ENGINEERING V.P. REPORTS:

"Dayton Cog-Belt® is doing a job

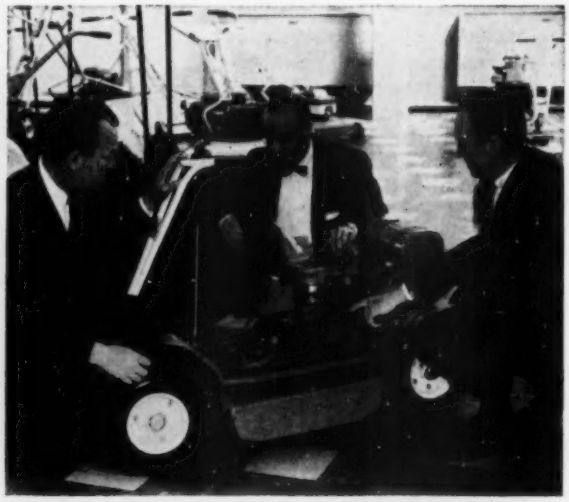
You see here a unique, unusually efficient V-Belt Drive . . . typical of the quality engineering which has made Jacobsen Manufacturing Company a leader in the power mower field since 1921.

Severe Drive Problems. Only trouble is, in *this* unit—a powerful 26 inch rotary mower—the efficient design also puts unusual demands on the belt drive system. Note, for example, the sharp reverse bend . . . the short, severe quarter-twist. Also realize that the drive, operating in a metal housing from 4¼ hp motor to high-speed cutter blade, is subjected to severe heat from the motor sheave.

Wrapped Belts Fail. The problem of belt life used to be so severe that Jacobsen engineers *couldn't keep a standard wrapped covered belt on the drive long enough to make any realistic tests!* According to Sherman Heth, vice president in charge of engineering for Jacobsen, "The backside idler caused the bottom side of a wrapped belt to crack. Also, the belt, because of the half-twist between motor and backside idler, would fight out of the sheave grooves. And heat plus shock loads would quickly deteriorate it.

Dayton Solves The Problem. "Then we tried the Dayton Cog-Belt. The Dayton Cog-Belt was unaffected by the heat! It has no cover, hence it didn't crack. Its cogs provide great flexibility, keep it tracking in the sheave grooves. The problem was solved! The Dayton Cog-Belt did then—and still is doing—what no other standard-type V-Belt could! We've had virtually no troubles, and the drive has worked well in the thousands of these mowers sold since!"

Powerful, easy-to-handle Jacobsen's popular 26-inch "Javelin" mows an acre an hour, travels uphill and down at speeds up to 5 mph. This powerful rotary mower can also pull a three-gang reel, a cart, roller, sweeper, or fertilizer spreader.



Jacobsen Vice President Sherman Heth (center) discusses the efficient, compact drive features of the Jacobsen "Javelin" with Tom Farrell, Dayton regional manager (left) and Bob Schreiber, Dayton sales engineer.

Drive Engineering Service. Perhaps the Dayton Cog-Belt can help solve your drive problems, too. A Dayton sales engineer will be glad to work with you. Phone or write us direct. Remember: ONLY DAYTON MAKES THE COG-BELT.

CIRCLE 54 ON READER SERVICE CARD

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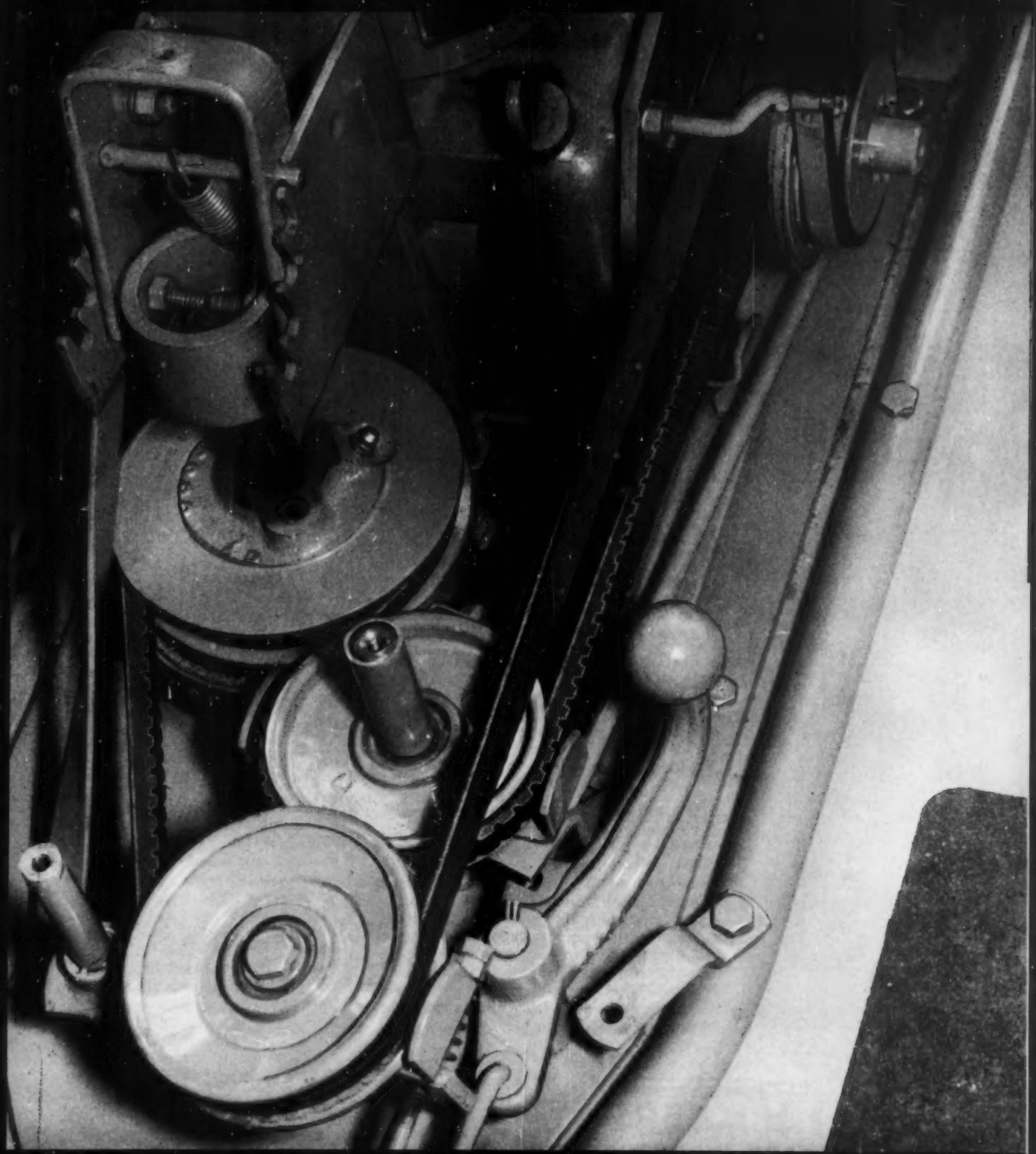
Dayco CORPORATION

Dayton Industrial Products Co. Div. Melrose Park, Illinois

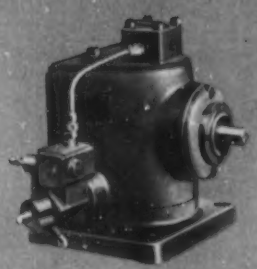
no other standard V-Belt could!



Jacobsen's unique motor-to-cutter drive requires the Dayton Cog-Belt to make a short severe twist and reverse bend between 3" motor sheave and 3¾" backside idler, and operate at high speeds under often-intense heat and abrupt shock.

EQUIPMENT BUILT BY AMF'S UNION MACHINERY DIVISION USES THESE VICKERS COMPONENTS

CUSTOM POWER PACKAGE—A double-ended 60 hp electric drive motor is the prime mover for the two main hydraulic drives—one powering the developer (30 to 50 hp), the other driving the incorporator (5 to 10 hp). Vickers also supplies auxiliary control valving as part of the complete package. For more details on customized or standard power packages contact your Vickers application engineer.



PISTON PUMPS—AMF's application employs variable-displacement pumps having electrical remote volume control. Industry's broadest standard line includes models with flows to 180 gpm and pressures to 5000 psi, plus a wide variety of controls. For additional information write today for Bulletins 61-81, 61-84 and Catalog 5001C.

HYDRAULIC MOTORS—This fixed-displacement motor is only one of a complete line that includes models for variable horsepower (constant torque) or constant horsepower (variable torque) output characteristics in ratings from fractional to hundreds of hp.

Vickers adjustable-speed hydrostatic drives offer many unique advantages and economies—especially for applications where there are problems of space, weight, fast acceleration, infinite speed or tension control, sudden braking or reversing, hazardous or corrosive surroundings.

VICKERS®

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1454 • Detroit 32, Michigan

psi and atomizing pressure of 90 psi. Bonding is accomplished after about 10 min. by firmly pressing brushed or sprayed sections together. Adhesive is of thin syrup viscosity and is used undiluted. Supplied in 1-, 5- and 54-gal. containers. **Schwartz Chemical Co Inc, 50-01 Second St, Long Island City 1, NY.**

Circle 311 on Reader Service Card

Transistor-equipped interval timers . . .

have no motors, clutches or solenoids and are available in eight models that cover range of 0.5 sec to 5 min. Timing interval is adjustable by a control knob or slotted shaft with locknut. Control contacts are rated at 5 amp noninductive load, 115 v ac. Standard models operate from 115-v, ac line, with 5-w power consumption (timers for operation on dc, as low as 28 v, can be supplied). **Electro-Seal Corp, 938 North Ave, Des Plaines, Ill.**

Circle 312 on Reader Service Card

Self-lubricating journal bearings . . .

handle dynamic loads to 25,000 psi and static yield loads to 50,000 psi at low rotational speed without damage. Have stainless steel housings and bushings with plastic alloy inserts. Bore sizes are from ¼ to 3 in. Life is said to be unlimited at unit loading of 10,000 psi or less with moderate surface speeds. At highest dynamic loading, no galling, fretting or brinelling reportedly occurs. At highest unit loading, 50,000 PV can be handled satisfactorily, but 150-ft-per-min. velocity should not be exceeded. **Southwest Products Co, 1705 S Mountain Ave, Monrovia, Calif.**

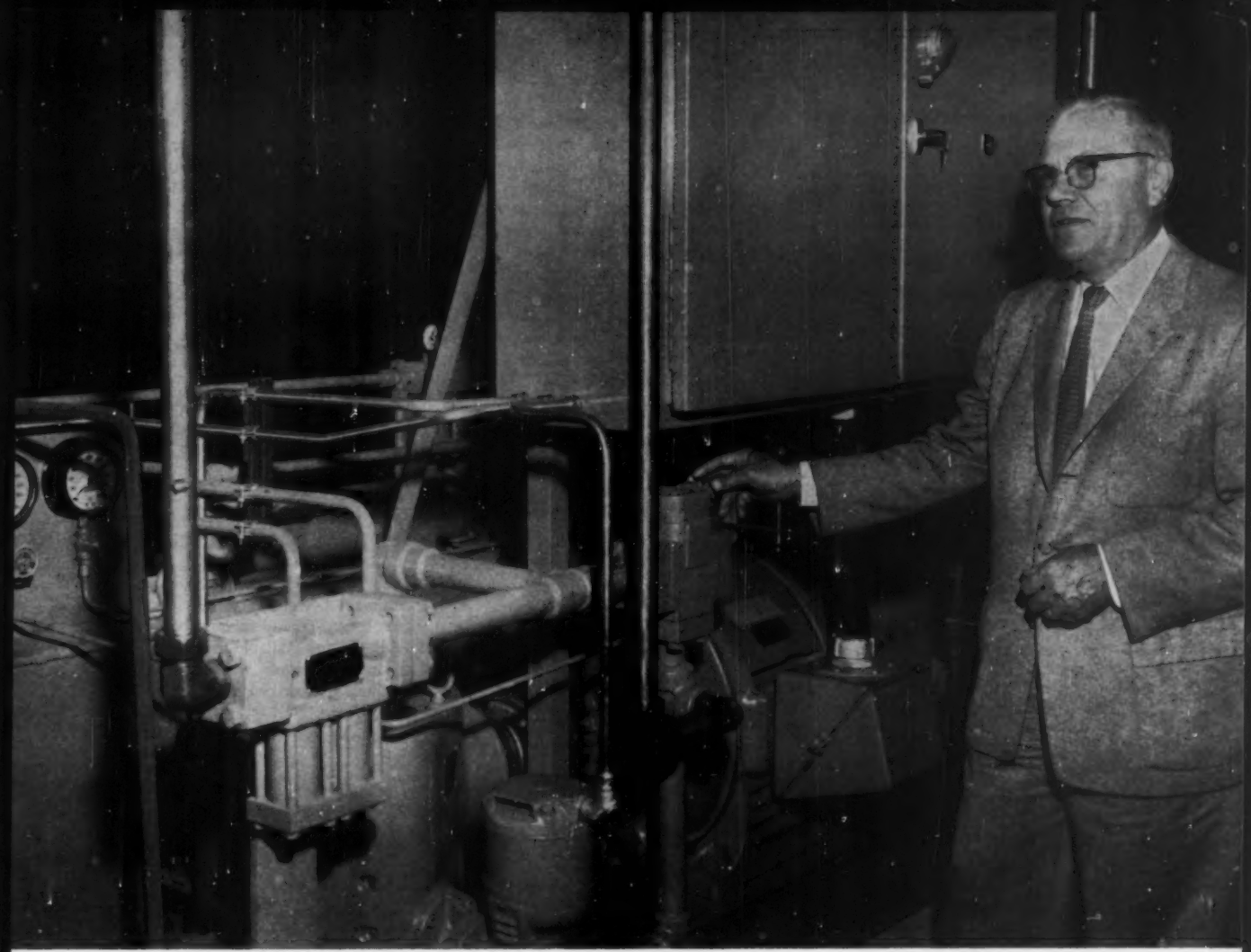
Circle 313 on Reader Service Card

3-phase protecting device . . .

is static, transistor-equipped unit that operates from voltage signals and protects personnel, motors and machinery against 3-phase voltage unbalance, phase failure or phase reversal. Can be used on either Delta or Wye 3- and 4-wire systems and unlike other complete phase protecting devices, unit continuously monitors 3-phase voltage circuits for both magnitude and phase relationship. When an unbalanced voltage condition exists, the transistorized electronic circuit triggers a circuit relay. Operating time is 30 to 52 millsec. Sensitivity adjustment is provided so that a preset operating level can be adjusted between 40 to 100 v of rated phase voltage. Device resets automatically

continued on page 58

← CIRCLE 56 ON READER SERVICE CARD



MELBURN B. HANCOCK, CHIEF ENGINEER, AMF'S UNION MACHINERY DIV., SAYS:

"Hydraulics give us compactness, easy clean-up..."

"... accurate speed control, and freedom from noise and vibration in the operating area. Because the use of adjustable speed hydrostatic transmissions on bread machinery was, in a sense, a pioneering effort, we found it essential and helpful to work closely with Vickers engineers in developing a completely workable system that offered our customers advantages unobtainable elsewhere.

"Our speed control must be accurate since any speed variation may degrade the end product. This speed control is required from about one-half speed to maximum speed of the equipment. Also, the system must be extremely flexible since operating speeds vary from time to time depending on characteristics of the raw material.

"With hydraulics we are able to reduce the overall size of the equipment for the production area where space is at a premium. Combined with other space saving design features, this machine is smaller than would otherwise be possible.

"Last ... but by no means least in the food industry ... is the ease with which the machine can be cleaned (firehoses are usually used to wash down equipment) because hydraulic units are sealed from external moisture, etc. This is a daily operation on breadmaking machinery and is a major advantage to commercial bakeries."

Whether your requirement is for a refinement to existing methods of applying hydraulics or a completely new approach to providing power and control to machinery, Vickers design and application engineers are ready to work with you to effect the most efficient and economical solution. See facing page for more details about components and systems used by Union Machinery Division, American Machine & Foundry Co., and the overall Vickers line.

9713

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when normal phase conditions return. Available for operation on 200-250, 380-440, or 550-575 v, 50/60-c power systems. **Industrial Electronic Div, Emerson Electric Mfg Co, 8100 Florissant Ave, St Louis 36.**

Circle 314 on Reader Service Card

Permanently flexible adhesive

is used for bonding natural and synthetic rubber, vinyl plastic, fabric, leather and wood to itself or to glass, steel, iron, aluminum, phenolic plastic and other surfaces. Material is a high solids adhesive and is said to be fast setting, extremely tough, waterproof and resistant to oil, gasoline, chemicals and outdoor weather. Available in qt, gal., 5-gal. and drum quantities. **Chemical Development Corp, Danvers, Mass.**

Circle 315 on Reader Service Card

Die-cast wing nut . . .

has capped head to prevent bolt ends from damaging and snagging other objects, to seal and protect bolt threads; low wing for snagproof limited top clearance installations; and washer base which speeds assembly by eliminating extra handling of washer, prevents marring of soft or brittle surfaces, and is useful with adjustment slots and oversize or offset holes. Wings incorporate fingergrip recesses. Available in 6-32, 8-32, 10-24, 10-32 and ¼-20 thread sizes. Over-all height is ⅜ in. and max wing spread, ⅞ in. Made of zinc alloy, fastener reportedly will not "freeze" on steel, aluminum or brass screws. From stock. **Gries Reproducer Corp, 400 Beachwood Ave, New Rochelle, NY.**

Circle 316 on Reader Service Card

Transistorized level control . . .

is made up of an electronic medium-frequency control module which comprises a static transistorized circuit mounted on a printed circuit board. Module is housed in a cast aluminum probe assembly which eliminates use of coaxial cables and permits relay control unit to be mounted at any distance from probe heads. Can be equipped with ceramic angle probes for use with powdered materials; heavy-duty probes for use with such materials as coal or gravel; flush probes for use in rotating stirrers; extension-type probes for use in detecting level of power plant fly ash buildup or level of cement or sand in large bins, etc. Available for single-phase operation on 115 or 230 v, 50/60 c or with 12 and 24-v batteries for use on static or mobile vehicles. **Industrial Electronics Div, Emerson Electric Mfg Co, 8100 Florissant Ave, St Louis 36.**

Circle 317 on Reader Service Card

Miniature time-delay relay . . .

is 1- or 2-pole, hermetically sealed unit with a time range from 15 sec to 30 min. or longer and repeat accuracy of ±2% of over-all time range. Switches are fast make, fast break, SPDT, rated 3 amp resistive and inductive at 125 v ac and 30 v dc and with life expectancy of 50,000 operations. Unit, measuring approx 1 x 2 x 4 in., uses 400-c (hysteresis) or 60-c (permanent magnet) 115-v motor and other space-saving modifications. Meets MIL tests, including operation at 70,000 ft, vibration from 10 to 2000 cps at 10 g's and 50-g, 11-ms shock. **Cramer Div, Giannini Controls Corp, Centerbrook, Conn.**

Circle 318 on Reader Service Card

Reversible variable-speed drives . . .

are available from 80-0-80 to 1200-0-1200 rpm with 1800 rpm input. Torque ratings are from 3-450 in.-lb. Reverse control is a separate knob or lever which is operated independently of the speed control lever. Reversing direction of input does not reverse output. Direction of output can be changed whether drive is running or not. Reverse on smaller drives is accomplished by reversing direction of the drive of the overrunning clutches in the output section. On larger drives, reverse is accomplished by a bell-crank and gear arrangement in a gearhead. When clutches are reversed in smaller drives, output shaft speed is changed, unless input direction is reversed at same time, or unless speed control lever is reset. When bell-crank mechanism is used for reverse, output shaft speed remains the same at any given speed control setting. Reverse control also provides a neutral position in which output shaft is disengaged and can be manually rotated in either direction. **Zero-Max Co, 2845 Harriet Ave S, Minneapolis 8.**

Circle 319 on Reader Service Card

Variable-speed drive . . .

has electronic control regulator in its power control package which eliminates need for a motor–generator set without sacrificing regulation or drift characteristics. Regulator continually monitors load and automatically corrects to hold dc motor speeds constant. Standard models offer regulation of 0.5 to 1% of set speed and drift of 0.05% with tachometer feedback and regulations of 1 to 2% and drift to 0.5% with armature feedback. Special units that regulate to 0.1 to 0.25% of set speed, regardless of varying load and voltage, are available for critical control. Drift in this case is limited to 0.025%. **Tenney Engineering Inc, 1090 Springfield Rd, Union, NJ.**

Circle 320 on Reader Service Card

Plotting scale . . .

a 4 x 8-in. plastic chart with variety of scales on both sides, replaces graph paper. Twelve log cycles, ranging from ¼ to 4 in. and three linear scales are arranged around the periphery for direct plotting use. In addition, two triangular charts—one linear and one logarithmic—provide precision divided scales of varying moduli. From stock at $2 each. **Technical Marketing Associates Inc, 33 Sudbury Rd, Concord, Mass.**

Circle 321 on Reader Service Card

Solid state strain gages . . .

include matched gages for variety of materials; gages for dynamic measurements which are said to provide 50 times greater output at ¼ the "apparent strain" of conventional high-output wire gages; small gages (0.1-in. gage length) for limited spaces; and gage factors from —140 to +170. Incorporated in flexible epoxy matrix and available in resistance ranges of 120 to 5000 ohm. **Kulite-Bytrex Corp, 50 Hunt St, Newton 58, Mass.**

Circle 322 on Reader Service Card

Switch kit . . .

is for construction of miniature rotary switches to be used in prototype development and lab work. Enables user to assemble up to 25 four-section switches, 1 7/16 and 1¼ in. dia. **Centerlab Electronics Div of Globe-Union Inc, 900 E Keefe Ave, Milwaukee 1.**

Circle 323 on Reader Service Card

DESIGN FOR SUPERIOR PERFORMANCE

with Lord

vibration/shock/noise control

how Lord can help improve performance

High-strength elastomeric mountings and joints are custom designed to control dynamic disturbances, reduce wear, accommodate relative motion . . . thereby upgrading performance, reliability, acceptance. These compact, easy-to-install units resist severe conditions, often outlast metal parts, never need lubrication.

on crawler tractors . . .

- **Engine mountings** isolate engine disturbances.
- **Radiator mountings** prevent fatigue failure.
- **Instrument panel mountings** improve instrument life and accuracy.
- **Seat mountings** enhance operator safety and comfort.
- **Load equalizer joints** absorb road shock, accommodate misalignment and relative motion.
- **Diagonal brace pivot joints** eliminate metal-to-metal contact and lubrication.
- **Trailer hitch mountings** absorb starting-stopping shock.

Crawler tractors can be designed for greater handling ease, lower maintenance requirements and longer component service life.

Lord-engineered vibration control is a proved route to this superior performance . . . and to the competitive edge it will give your product.

Suggested here are seven performance-improving ideas which should be considered early in the design of your next model. Utilizing rubber with a backbone of steel, Lord mountings cushion brutal jolts, isolate damaging vibration, "give" under frame distortion. As a result, your tractor rides easier and handles better, components last longer and need fewer repairs.

Lord engineers are ready to help you design for superior performance. Take advantage of Lord experience—contact your nearest Field Engineering Office or the Home Office, Erie, Pennsylvania.

LORD®

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA · CEdar 7-9247
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DAYTON, OHIO · BAldwin 4-0351
DETROIT, MICH. · Diamond 1-4340
KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. HOllywood 4-7999
NEW YORK, N. Y. (Paramus, N. J.)
New York City BRyant 9-8042
Paramus, N. J. Diamond 3-5333
PHILADELPHIA, PA. PEnnypacker 5-3599
SAN FRANCISCO, CAL. EXbrook 7-6280
WINTER PARK, FLA. Midway 7-5501

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LORD MANUFACTURING COMPANY · ERIE, PA.

Where in the world can I get a gear train with a 180 to 1 reduction ratio with a maximum error factor of ±1 minute of arc assured after 2000 hours under a 25 ounce load on the output shaft?

Sounds like a tall order but Dynaco can meet it. Fact is, they recently designed a similar system which proved itself to be 100% more accurate than the specs required. That's the kind of precision design and fabrication you can always expect when Dynaco tackles a problem.

For millions of precision motions . . . the world turns to Dynaco.

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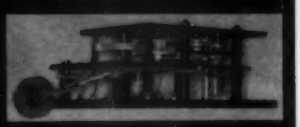
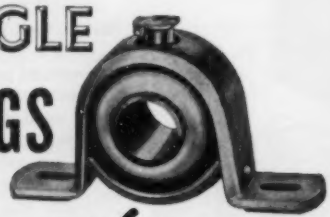


WESTERN DIVISION: 8912 Sepulveda Blvd., Van Nuys, California P.O. Box 4156 • Telephone: EMpire 2-3125 • Teletype: SNFD-4436

CIRCLE 70 ON READER SERVICE CARD

TRIANGLE BEARINGS with *Engineered* INDIVIDUALITY



Triangle fits the bearing to the application. Whether you can use a standard, like the Pillow Block above, or need a special such as the Pedestal or Clamshell Bearings shown below, your particular bearing problem receives the individual attention best assuring cost reductions — quality improvements.

SELF-ALIGNING . . . SELF-LUBRICATING SLEEVE-TYPE PILLOW BLOCKS

The widest selection of mountings available — functionally designed, efficiently produced. Experienced sales engineers available to help you anywhere. Phone or write for descriptive literature.

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All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

DESIGN LITERATURE

Creative Engineering Analysis

FREDERICK L RYDER. Prentice-Hall, Inc, Englewood Cliffs, NJ. 6¼ x 9½, 281 pp. $9.00.

This book offers step-by-step aid in applying academic knowledge to the solution of workaday engineering problems. This is done through detailed examples in many different fields, especially in mechanics, strength of materials, and electricity and electronics, in which the reader is shown how to strip the problem of non-essentials, translate the essential relationships into practical mathematical form for convenient analysis, carry through the analysis, translate the results of mathematical analysis into meaningful physical conclusions.

Typical problems involve errors of a rate gyro, truss-frame combination, E-core servo motor, and gamma-ray shielding. In addition to worked-out problems, the book contains many problems with partial answers to encourage reader self-development. A special feature which will aid problem solution is the complication of tricks and devices of analysis.

Toughness of Laminated Steel Sheet:

S. V. ARNOLD, Watertown Arsenal. PB 171044 (WAL TR 834.21/2). Office of Technical Services, U S Dept of Commerce, Washington 25, DC. 8¼ x 10¾, 25 pp. $0.75.

In certain temperature ranges, a laminated metal structure built up from several thin sheets will have higher impact strength than a solid piece of the same thickness. Impact data in this report was obtained on AISI 4340 hardened and tempered to various strength levels from 165,000 to 210,000 psi tensile.

The Relay Guide

RAYMOND N AUGER, Technical Editor, Automatic Control, Reinhold Publishing Co, 430 Park Ave, NY 22. 8½ x 11¼, 399 pp. $10.00.

This comprehensive literature survey (catalogs and standards) includes almost all published data on hundreds of available models of relays from approximately 200 manufacturers. The guide presents application data, relay circuits, arc suppression information, relay definitions and terms, and relay descriptions. Types of relays included are: general purpose, telephone, miniature, rotary, power, plunger (solenoid), motor starting, high voltages, vacuum, mercury, sensitive, polarized, high speed (keying), snap action, radio frequency antenna, coaxial, high frequency, video, subminiature, latching (toggle), frequency sensitive, stepping switch, electronic, time delay, overload, special purpose. Appendix has relay testing techniques.

ABSTRACTS FROM THE LITERATURE

Vanadium in Steel

Vanadium as an alloying element in steel is designed in the first instance to elevate the temperature at which the steel begins to show an enlargement of the grain size, so that in effect it produces a more refined microstructure. Secondly, vanadium in steel has the effect of making it more hardenable, as long as certain conditions are fulfilled. The refinement of grain structure is caused by the ability of the element to form carbides. Vanadium also forms oxides and nitrides, and it is in considering the influence of these that the study of the binary vanadium systems becomes important.

"Vanadium in Steel," Mechanical World, July 1960, 31 King St W, Manchester 3, England

Engineering Curriculum Examined

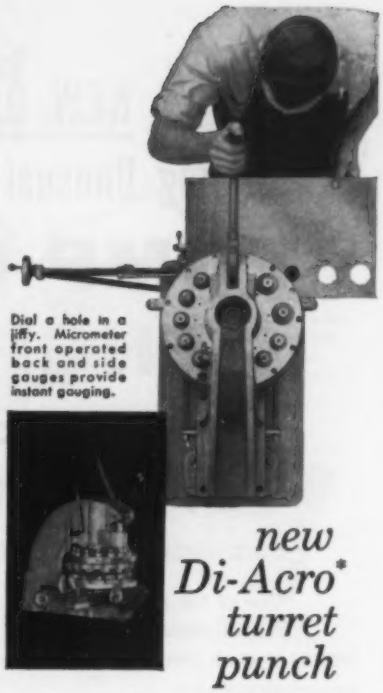
There is continued agitation for changes in the curriculum, fundamental changes involving the philosophy on which the curriculum is set up. What does industry ask of the mechanical-engineering graduate? The article discusses these points.

"Let's Examine the Engineering Curriculum," by E. H. Case, Deere & Co, Moline, Ill., Mechanical Engineering, Oct 1960, American Society of Mechanical Engineers, 29 W 39th St, NY 18.

Test Methods for Vinyl

This article reviews the current status of a number of vinyl plastics test methods that are being developed or have been recently adopted by ASTM. Attention is primarily directed toward methods applicable to flexible,

continued on page 62



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Accurate Burr-Free Punching at 12 Rotating Stations

The new Di-Acro 4 Ton Turret Punch Press provides rapid, close tolerance punching of round, square, oval and rectangular holes from 1/16" to 2".

Rotating turrets provide rapid indexing for single or sequence punching. Precision hole location quickly obtained with Micro-twin gauges. Punches sheet metals up to 16 gauge mild steel, fibreboard, asbestos, paper, cork, leather, rubber, plastic and other sheet materials.

Dies are mounted in turrets —always handy. Standard clearance between punch and die is .002". Choice of 6 other clearances at no charge. The Di-Acro Turret Punch Press is safe, simple to operate—requires little maintenance.

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*pronounced die-ack-ro

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formerly
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NEW OPENING

Offering Unusual Career Potential

PUMP DESIGN ENGINEER

...over $10,000 salary bracket

One of the nation's leading manufacturers of products for the industrial, consumer and defense markets has a recently created position for an experienced centrifugal Pump Design Engineer. This position offers outstanding personal as well as professional potential with a company not now engaged in the manufacture of pumps, but of advanced systems in which pumps—(10 to 1500 hydraulic h.p. range)—are incorporated.

RESPONSIBILITIES

You will assume full technical responsibility for pump design and development, and for providing pump application data on these designs. You will also provide consulting services to engineers designing the systems in which your pumps will be used.

QUALIFICATIONS

BSME together with an MS (or the equivalent in experience). Minimum experience requirements include 5 to 10 years with a pump manufacturer—preferably in fluid mechanics and/or centrifugal pump design. You must also be able to meet and favorably impress our customers.

Location is in the Northeast. You will have full access to computers, extensive testing facilities, consultants and laboratories.

Qualified applicants will be invited to visit our facilities at Company expense. Relocation assistance will be provided. Additional information about our extensive benefits program for employees and dependents will be provided.

Please include enough information about your education and experience to justify further consideration for a position of this salary and responsibility level. All qualified applicants will be considered for employment without regard to race, creed, color or national origin. 8J-549

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plasticized compositions of polyvinylchloride resin.

"Advances in Vi... ...stics Test Methods," by J. B. DeCoste, B... ...elephone Laboratories, SPE Journal, Oct 19..., Society of Plastics Engineers, 65 Prospect St, Stamford, Conn.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

FLEXIBLE CUSHION COUPLINGS—Bulletin 901B, 24 pp. Covers standard, high-speed and flywheel types, tabulating hp ratings, dimensions, prices and weights. Includes cutaway and engineering drawings and actual installation photos. Dodge Mfg. Corp, Mishawaka, Ind.

Circle 350 on Reader Service Card

SPIRAL WOUND GASKETS—Brochure Ad-176, 20 pp. Reviews gasket construction, specifications, flange face finish, bolting data, metal temperature range and style details of asbestos-, Teflon- and ceramic-filled types. Outline drawings are included. Garlock Inc, Palmyra, NY.

Circle 351 on Reader Service Card

STAINLESS STEELS—Booklet 1223, 32 pp. Discusses precipitation hardenable types, just what the process is and how it is accomplished. Also contains tabulated data and curves on heat treatments, mechanical properties and fabrication for four PH types, Republic Steel Corp, Advertising Div, 1441 Republic Bldg, Cleveland 1.

Circle 352 on Reader Service Card

ROLLER CHAINS, SPROCKETS—Catalog 8, 106 pp. Gives design details of power transmission components, outlining methods of chain adjustments on movable and fixed sprocket center drives, plus hp, speed, size and price data on complete line. Includes diagrams, outline drawings and photos. Acme Chain Corp, 821 Main St, Holyoke, Mass.

Circle 353 on Reader Service Card

VALVES AND FITTINGS – Catalog 60-B, 36 pp. Covers two series for 1500 and 6000-psi liquid or gas service, tabulating sizes and pressure ranges. Describes soft-seated valve closure principle and use of O-rings for leakproof connections. Cutaways illustrate design features. Combination Pump Valve Co, 848 Preston St, Philadelphia 4.

Circle 354 on Reader Service Card

ELECTRICAL CONTACTS – Booklet, 8 pp. Contains tables covering applica-

continued on page 63

tions and properties of various contact alloys and specifications of most commonly used contacts. Discusses points to be considered in design, specification and purchase of rivet contacts, laminated contacts, spring and blade components and complete assemblies. Tricon Mfg Co, 8010 S Wallace, Chicago.

Circle 355 on Reader Service Card

VINYL AND RUBBER PARTS—Brochure G-61, 16 pp. Gives characteristics, properties of molded and extruded vinyl and rubber parts, including one-piece dual-durometer transfer molded parts; parts made by dual-compound extrusion process; and rubber extruded over rigid metal for electrical insulation. Tabulates specifications from RMA handbook as guide to selection of tolerances and finishes. Geauga Industries Co, Middlefield, Ohio.

Circle 356 on Reader Service Card

CONTROLLED SPEED SYSTEMS—Brochure F-1952, 8 pp. Schematics illustrate discussions of 12 typical systems for such applications as liquid level control, pressure control, centerwind drive, speed sensitive control for extremely constant speed regardless of load fluctuations, load control, temperature control, etc. US Electrical Motors Inc, PO Box 2058 Terminal Annex, Los Angeles 54.

Circle 357 on Reader Service Card

PILOT LIGHTS—Brochure L-161C, 24 pp. Contains illustrations, lamp data, physical and electrical characteristics, etc. of sub-miniature indicator lights; pilot lights with built-in resistors for neon lamps; enclosed assemblies for neon and incandescent lamps; oil-tight indicators lights, etc. Dialight Corp, 60 Stewart Ave, Brooklyn 37, NY.

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HEAVY TUNGSTEN ALLOY—Bulletin B-500, 8 pp. Lists properties of material and uses in fields of radioactive shielding, balancing and high inertia rotational applications. Plots physical properties vs sectional thickness and reviews machining and joining recommendations. Kennametal Inc, Latrobe, Penna.

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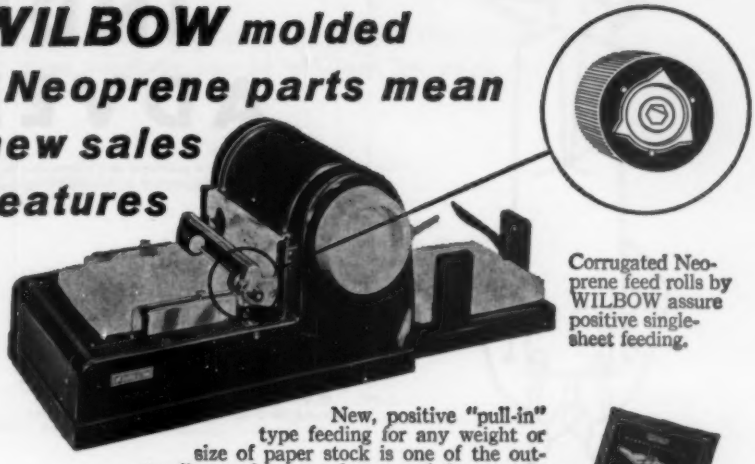
FOR MORE CATALOGS AND BULLETINS

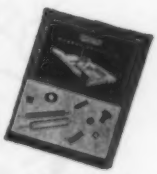
. . . 1600 of 'em—see your copy of Product Engineering's Mid-Sep 1960 Design Digest. There you will find helpful design literature, classified under 10 different headings, from important manufacturers and suppliers of components, materials, power and local systems, manufacturing processes.

WILBOW molded Neoprene parts mean new sales features



Corrugated Neoprene feed rolls by WILBOW assure positive single-sheet feeding.

New, positive "pull-in" type feeding for any weight or size of paper stock is one of the outstanding performance features of the recently introduced *Liberator 600* Duplicator by Speed-O-Print Corporation. To produce the specially engineered feed rolls required, with precisely controlled characteristics of size, yield, texture and wear resistance, Speed-O-Print called on WILBOW.



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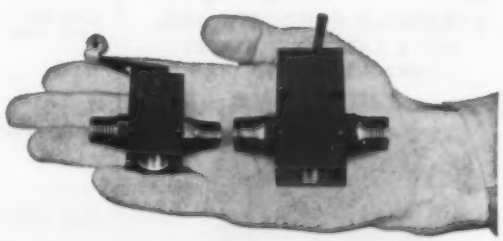
- For Pressure or Vacuum Service



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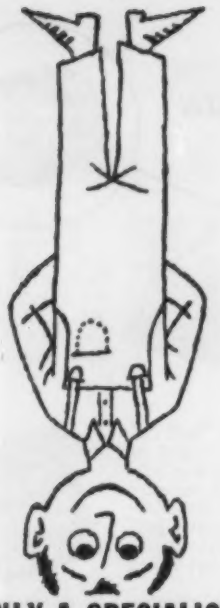

ONLY A SPECIALIST CAN MAKE CHECK VALVES SO WELL THAT THEY WORK PERFECTLY

UPSIDE DOWN

or in *any* position. In Strataflo No. 300, a sensitive spring closes the poppet automatically. Flexible, silicone-treated rubber poppet can't leak, opens easily, is tough and resistant to acids and abrasive-carrying liquids, operates noiselessly at minimum pressures. Special designs for submersible pump installations, gasoline and oil applications. Combination check valve/strainer available. Write for Bulletin 905 or telephone Harrison 3313 today.

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4939 S. LAFAYETTE STREET
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599—THE RIGHT INSULATION

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600—SELECTION GUIDE TO HIGH-DAMPING MATERIALS

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A comparison table plus a few quick calculations with these efficiency factors will help choose the best for your design.

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605—FIBERGLASS-REINFORCED THERMOPLASTICS

They are closing the performance gap between thermoplastics and metals.

606—THREADED INSERTS

Types available, factors governing selection, strength and cost characteristics.

607—SYNCHRONIC INDEX OF GEAR TRAINS

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608—HOW TO LISTEN—AND REMEMBER

Here's what the psychologists say will improve your "listening power."

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612—VALUE IN DESIGN

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613—FAILURE ANALYSIS

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614—TOMORROW'S POWER SOURCES

14 mobile power sources to generate from 1 to 500 hp.

615—NEW GEAR CLASSIFICATION

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616—UNCONVENTIONAL POWER SOURCES

8 laboratory curiosities promise power for the future.

617—METAL FINISHES

From paints to bonded lubes—what they can do, how they compare.

618—MECHANICAL COUNTERS

What is available for over 1000 rpm—the types, their strengths and weaknesses.

n this wealth of information

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313—Self-lubricating Journal Bearings

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357—Controlled Speed Systems, 8 pp, US Electrical Motors Inc

ELECTRICAL, ELECTRONIC COMPONENTS

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358—Pilot Lights, 24 pp, Dialight Corp

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354—Valves and Fittings, 36 pp, Combination Pump Valve Co
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PRODUCT ENGINEERING
Card expires September 22, 1961

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RIDGEFIELD, CONNECTICUT

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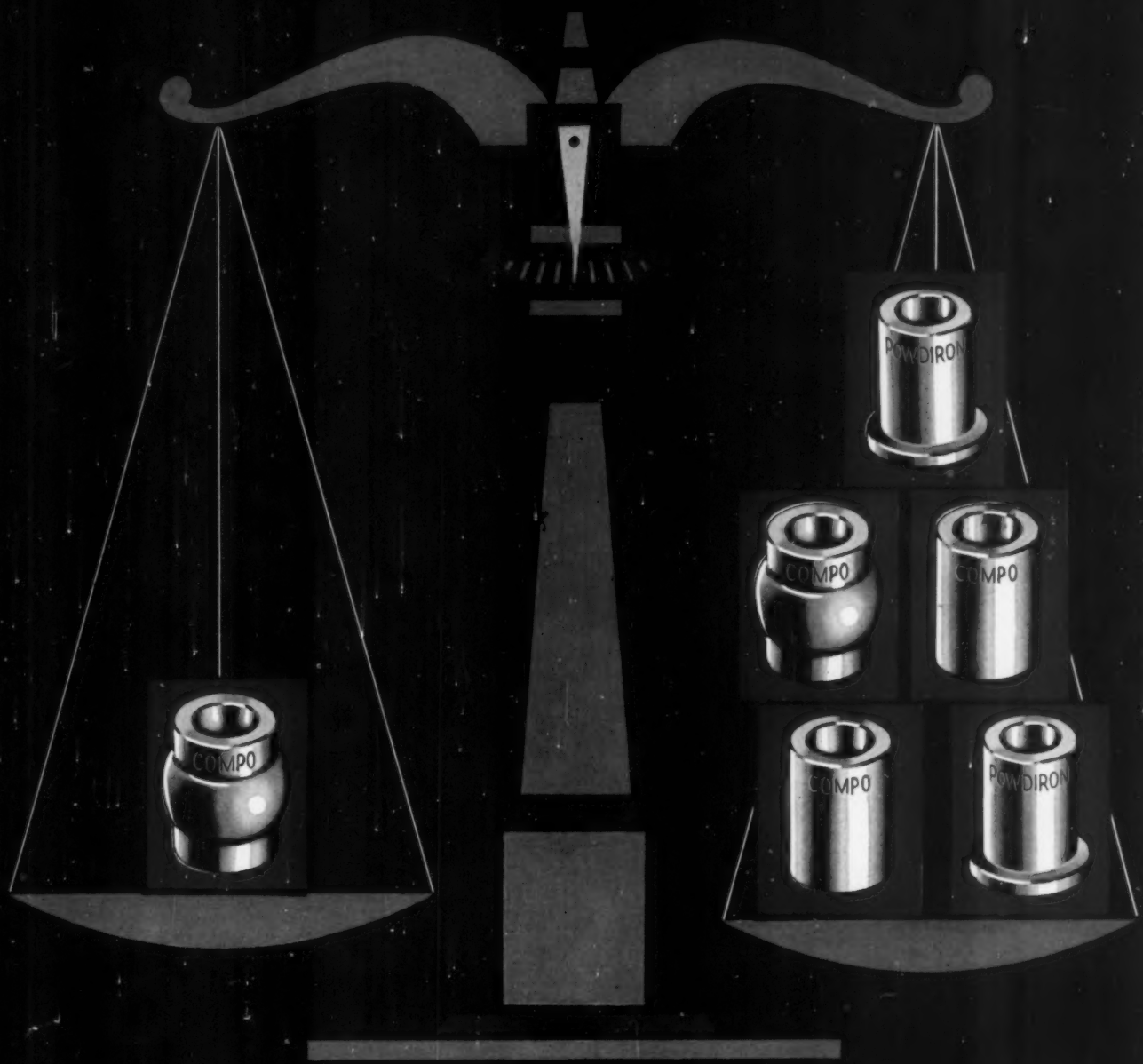

Every bearing order "weighs" the same at Bound Brook

We give the same special attention to each order . . . every step of the way, from engineering through production through shipping. Our two manufacturing plants give us the extra flexibility to meet equally well the needs of the smallest manufacturer . . . or the largest. Whatever your quantities and designs for self-lubricated iron and bronze bearings . . . you can rely on Bound Brook for "custom" service and prompt deliveries.

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C/R®

DESIGN NOTES

C/R offers new bonded CRS Seal design in standard sizes — without premium tooling charges

Design Advantages

The CRS Seal now provides a new level of C/R Seal performance through its simple, bonded design. There are no internal parts to misalign, no avenues for internal leakage. The shell and sealing member are integral — bonded securely for the long life of the seal. The CRS Seal incorporates a sealing member with both improved lip configuration and improved concentricity. The sealing member has been strengthened over former designs by placing more material at points of major flex and wear — and without increased shaft loading.

Designer Advantages

The CRS Seal gives the designer one, basic, rugged shaft seal design which may be applied with high reliability to the great majority of common shaft seal applications — particularly in industrial, automotive, farm, and off-the-road equipment.

Four basic design variations are available. As you can see, these provide an auxiliary sealing lip, where it may be required, or provide extra rugged shell construction where conditions suggest the need to protect the seal lip against assembly damage — or where large, heavy-duty shafts are being sealed.

Selection of the new C/R Type CRS Seal gives the designer and buyer major advantages over special seals: shorter lead time on orders, simpler specification, savings in time and money, and improved assembly quality and reliability.

Operating Maximums*

Shaft Speeds	3600 fpm (single lip) 2500 fpm (double lip)
Run-out	.015" TIR dynamic eccentricity .010" static eccentricity
Temperature	−30 to +275°F. (225°F. in EP lube)
Pressure	5 psi (single lip) 10 psi (double lip)
Media	Oil, grease, fuel, water

Not all conditions present in one application

New, Improved Compound

Standard sealing members for the C/R Type CRS Seal are molded of a new Sirvene synthetic rubber compound having markedly superior sealing and wearing properties. It is a Buna-N-based material with low-friction characteristics. The CRS Seal can also be furnished in the usual special materials such as acrylates, Silicones, and butyls. Shells are of standard steel, but can be provided in corrosion-resistant materials on special order.

Consult C/R Engineers

For assistance on the application of the new CRS — or on any oil seal problem, get in touch with C/R Oil Seal Engineers. They're specialists in fluid sealing — and will gladly cooperate with you.

For More Design Data:

You will want the complete design data on the new CRS Seal. Write for our Bulletin CRS-100. It gives you the complete list of standard sizes, widths, O.D.'s, shell thicknesses and sealing lip heights. You will want it to compare and then specify C/R's CRS Seal.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1237 Elston Avenue • Chicago 22, Illinois

Offices in principal cities

See your telephone directory

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

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